October 1993
£ 2.45

ELEKTOR ELECTRONICS

THE INTERNATIONAL
ELECTRONICS MAGAZINE

ML 2035/2036 application:
Programmable sine wave generator

AUDIO & HI-FI • COMPUTERS & MICROPROCESSORS • DESIGN IDEAS • RADIO, TELEVISION & COMMUNICATIONS • SCIENCE & TECHNOLOGY • TEST & MEASUREMENT

VHF/UHF TUNER

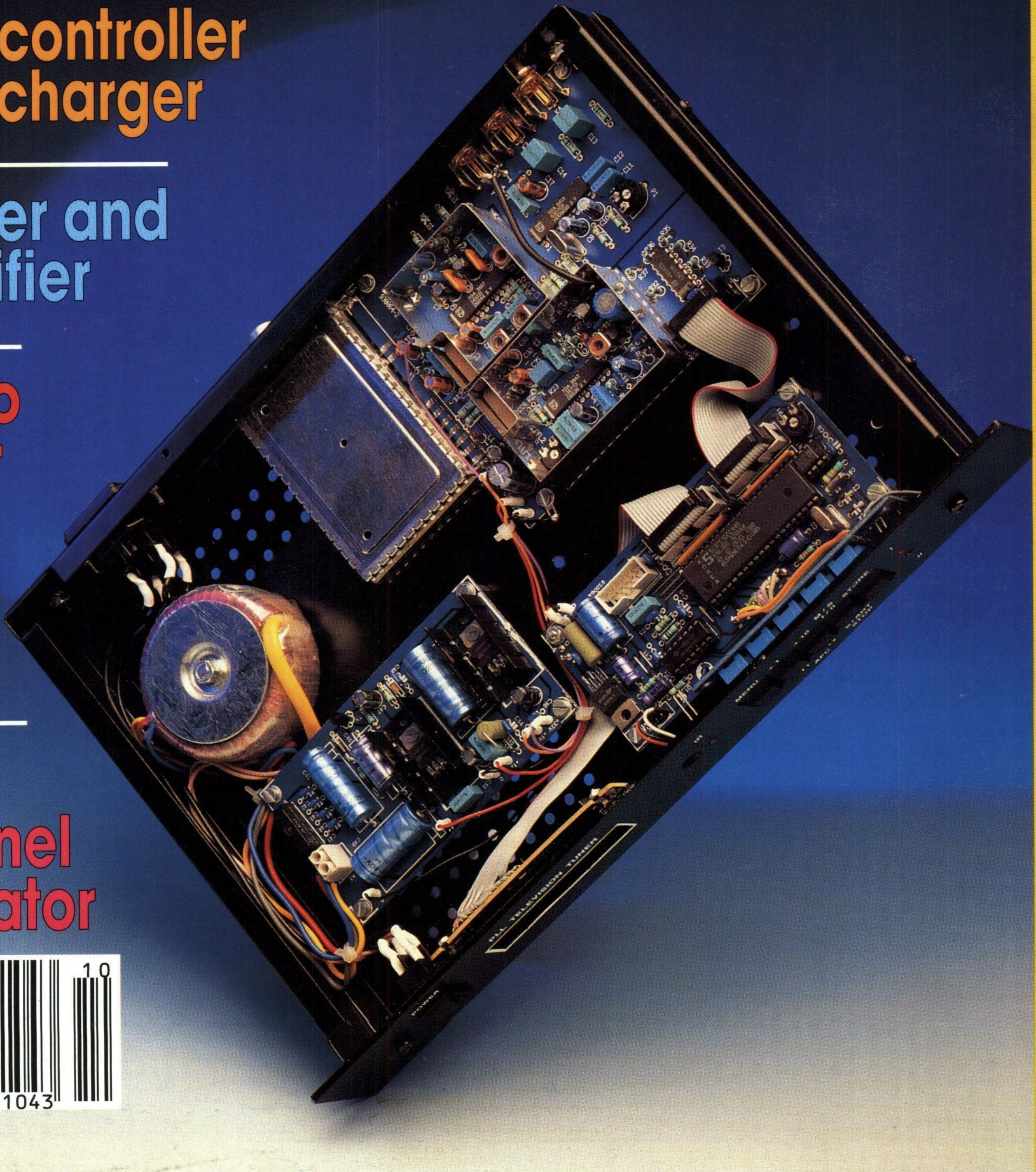
Microcontroller NiCd charger

AF filter and amplifier

Stereo mixer

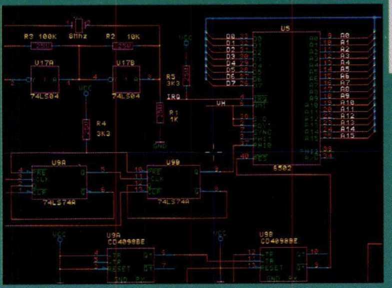
Ah meter

MIDI channel indicator

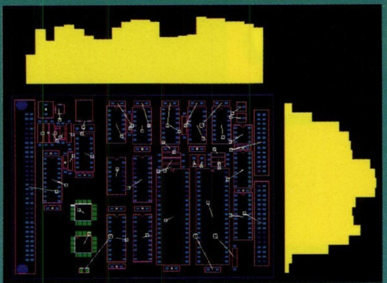


10
9 770268 451043

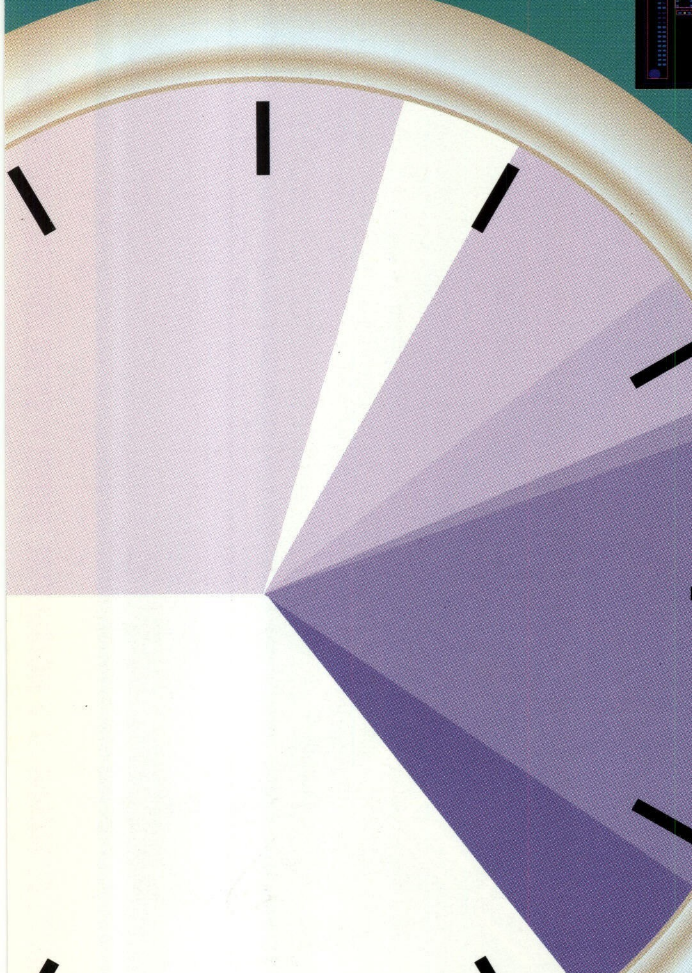
FROM CONCEPT TO ARTWORK IN 1 DAY

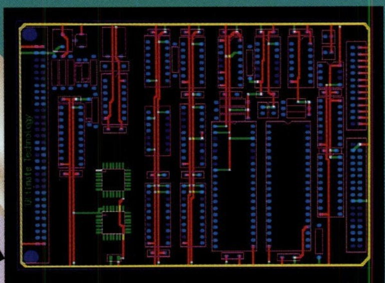


Your design ideas are quickly captured using the ULTIcap schematic design Tool. ULTIcap uses REAL-TIME checks to prevent logic errors. Schematic editing is painless; simply click your start and end points and ULTIcap automatically wires them for you. ULTIcap's auto snap to pin and auto junction features ensure your netlist is complete, thereby relieving you of tedious netlist checking.

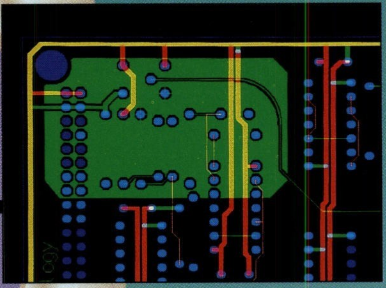


ULTIshell, the integrated user interface, makes sure all your design information is transferred correctly from ULTIcap to ULTIboard. Good manual placement tools are vital to the progress of your design, therefore ULTIboard gives you a powerful suite of REAL-TIME functions such as, FORCE VECTORS, RATS NEST RECONNECT and DENSITY HISTOGRAMS. Pin and gate swapping allows you to further optimise your layout.

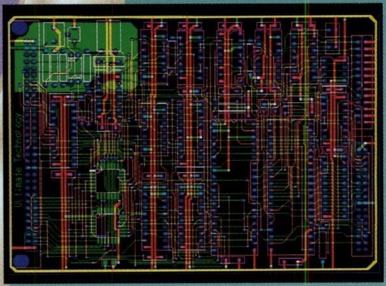




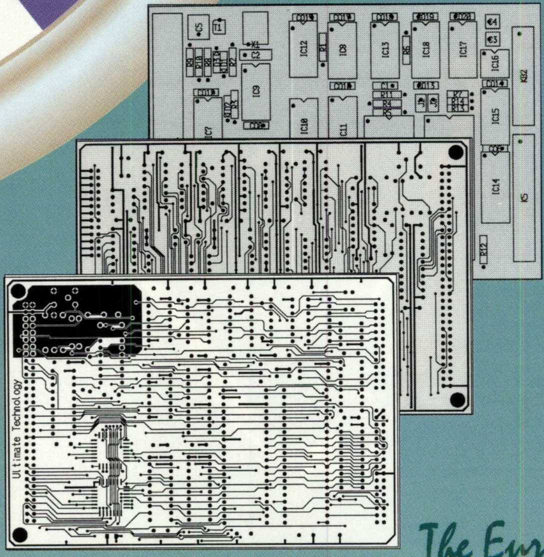
Now you can quickly route your critical tracks. ULTIboard's REAL-TIME DESIGN RULE CHECK will not allow you to make illegal connections or violate your design rules. ULTIboard's powerful TRACE SHOVE, and REROUTE-WHILE-MOVE algorithms guarantee that any manual track editing is flawless. Blind and buried vias and surface mount designs are fully supported.



If you need partial ground planes, then with the Dos extended board systems you can automatically create copper polygons simply by drawing the outline. The polygon is then filled with copper of the desired net, all correct pins are connected to the polygon with thermal relief connections and user defined gaps are respected around all other pads and tracks.



ULTIboard's autorouter allows you to control which parts of your board are autorouted, either selected nets, or a component, or a window of the board, or the whole board. ULTIboard's intelligent router uses copper sharing techniques to minimise route lengths. Automatic via minimisation reduces the number of vias to decrease production costs. The autorouter will handle up to 32 layers, as well as single sided routing.



ULTIboard's backannotation automatically updates your ULTIcap schematic with any pin and gate swaps or component renumbering. Finally, your design is post processed to generate pen / photo plots, dot matrix/laser or postscript prints and custom drill files.

NEW

ULTIboard/ULTIcap evaluation system:
- **all** features of the bigger versions
- full set of manuals
- design capacity 350 pins

Price incl. S & H, excl. VAT: **£ 75**

Purchase price is 100% credited when upgrading to a bigger version. • *Also suitable for study & hobby*

ULTIboard PCB Design/ULTIcap Schematic Design Systems are available in low-cost DOS versions, fully compatible with and upgradable to the 16 and 32 bit DOS-extended and UNIX versions, featuring unlimited design capacity.

The European quality alternative

ULTICAP + ULTIBOARD = MAXIMUM PRODUCTIVITY

ULTImate Technology UK Ltd. • 2 Bacchus House, Calleva Park, Aldermaston Berkshire RG7 4QW • Fax: 0734 - 815323 • Phone: 0734 - 812030

ELEKTOR ELECTRONICS

CONTENTS

October 1993
Volume 19
Number 215
ISSN 0268/4519

We regret that owing to unforeseen circumstances 'Low frequency filter' has had to be carried over to next month, when it will be titled 'Output amplifier with AF band-pass filter'.

In next month's issue

- Output amplifier with AF band-pass filter
- Telephone-controlled switch
- The analogue subsystem – Part 3
- 535 board with EPROM emulator
- VHF/UHF TV tuner – Part 2
- Precision clock for PCs
- Power MOSFET tester
- Electronic load resistance
- and others for your continued interest

Front cover
Adding a suitable colour monitor to the tuner described on pp 8–12 forms a complete television receiver. Microprocessor-controlled, menu-driven, with digital tuning, a small LCD screen, optional infra-red remote control, and a memory capacity for up to 100 preset stations, the tuner is also suitable for TV DXing and interfacing to a computer system via a video digitizer. It gives full coverage of the VHF and UHF television bands.

Copyright © 1993 Elektuur

ABC
AUDIT BUREAU OF CIRCULATIONS
CONSUMER PRESS

APPLICATION NOTE

40 Programmable sine wave generators 2035 & 2036
A Micro Linear Application

AUDIO & HI-FI

44 **PROJECT**: Stereo mixer
Design by Q. Gregory

COMPUTERS & MICROPROCESSORS

58 **PROJECT**: ROM gate switch-over for Atari ST
Design by E. Gilissen

ELECTRONICS & MUSIC

64 **PROJECT**: MIDI channel monitor
Design by W. Dunczewski

GENERAL INTEREST

48 **COURSE**: Figuring it out – Part 9: Reactive networks
By Owen Bishop

POWER SUPPLIES & BATTERY CHARGERS

30 **PROJECT**: Microcontroller-driven NiCd battery charger
Design by A. Rietjens

RADIO, TELEVISION & COMMUNICATIONS

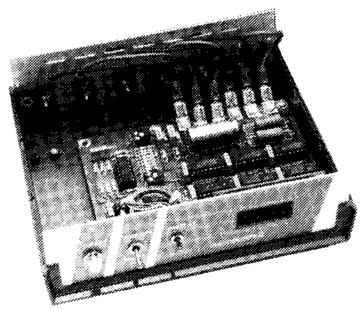
8 **PROJECT**: VHF/UHF television tuner – Part 1
Design by W. Sevenheck

TEST & MEASUREMENT

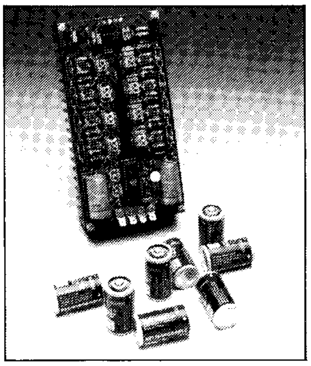
16 **PROJECT**: Ah meter with digital display
Design by K. Bachun
22 **PROJECT**: Fuzzy logic multimeter – Part 2
Design by H. Scholten
52 **PROJECT**: Autoranging frequency readout
Design by H. Kühne

MISCELLANEOUS INFORMATION

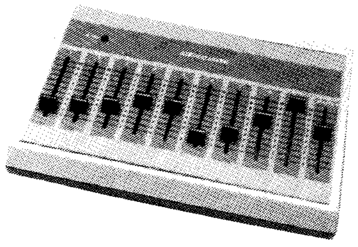
Buyers' guide **74**
Electronics scene **5**
Index of advertisers **74**
Readers' services **70-71**
Switchboard **69**
Terms of Business **72**



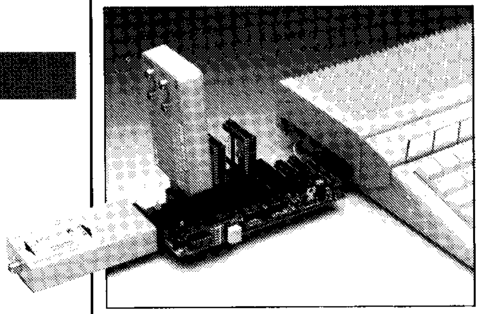
Ampere-hour meter - page 16



Microcontroller-driven NiCd battery charger - page 30



Stereo mixer - page 44



ROM gate switch-over for Atari ST - page 58

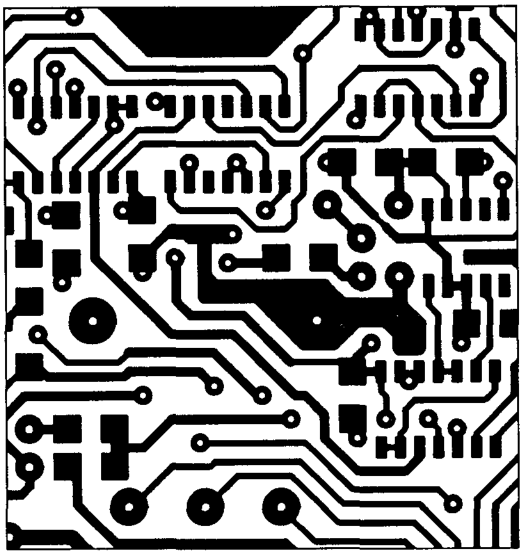
Elektor Electronics is published monthly, except in August, by Elektor Electronics (Publishing), P.O. Box 1414, Dorchester, Dorset DT2 8YH, England. The magazine is available from newsagents, bookshops, and electronics retail outlets, or on subscription at an annual (1994) post paid price of £27·00 in the United Kingdom; air speeded: £34·00 in Europe; £43·00 in Africa, the Middle East and South America; £45·00 in Australia, New Zealand and the Far East; and $57.00 in the USA and Canada. Second Class Postage paid at Rahway N.J. Postmaster: Please send address corrections to Elektor Electronics, c/o Mercury Airfreight International Ltd Inc., 2323 Randolph Avenue, Avenel, New Jersey, N.J. 07001.

EASY-PC, SCHEMATIC and PCB CAD

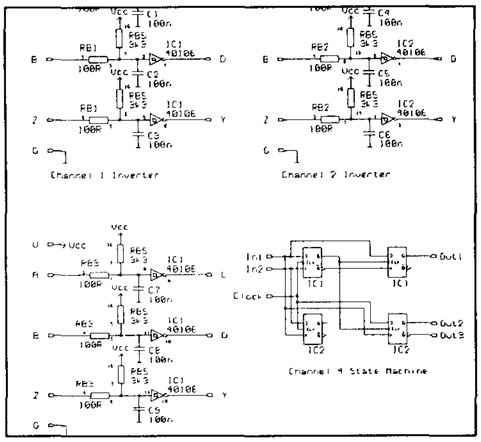
Over 17,000 Installations in 70 Countries World-wide!

Still Only £98.00! Plus P&P+VAT

BRITISH DESIGN AWARD 1989



- Runs on:- PC/XT/AT/ 286/ 386/ 486 with Hercules, CGA, EGA or VGA display and many DOS emulations.
- Design:- Single sided, Double sided and Multi-layer (8) boards.
- Provides full Surface Mount support.
- Standard output includes Dot Matrix / Laser / Ink-jet Printer, Pen Plotter, Photo-plotter and N.C. Drill.
- Tech Support - free.
- Superbly easy to use.

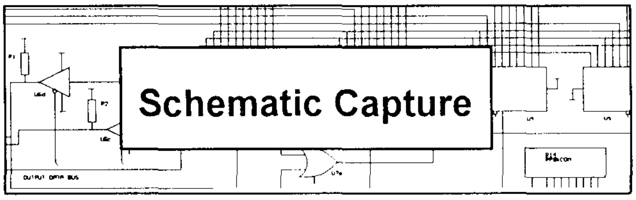


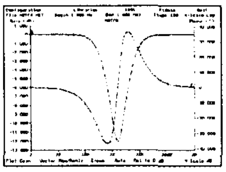
Options:-500 piece Surface Mount Symbol Library £48, 1000 piece Symbol Library £38, Gerber Import facility £98.

Electronic Designs Right First Time?

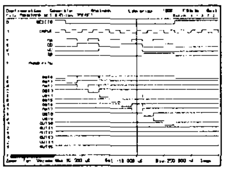
Ask for our fully functional Integrated Demo

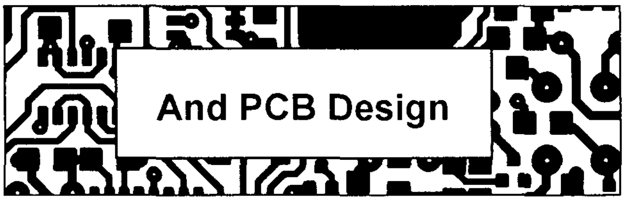
Integrated Electronics CAD





Analogue & Digital Simulation





For Less than £400/$775!

Affordable Electronics CAD

EASY-PC: Low cost, entry level PCB and Schematic CAD.	**$195.00**	**£98.00**
EASY-PC Professional: Schematic Capture and PCB CAD. Links directly to ANALYSER III and PULSAR.	**$375.00**	**£195.00**
PULSAR: Low cost Digital Circuit Simulator ~ 1500 gate capacity.	**$195.00**	**£98.00**
PULSAR Professional: Digital Circuit Simulator ~ 50,000 gate capacity.	**$375.00**	**£195.00**
ANALYSER III: Low cost Linear Analogue Circuit Simulator ~ 130 node capability	**$195.00**	**£98.00**
ANALYSER III Professional: Linear Analogue Circuit Simulator ~ 750 node capability.	**$375.00**	**£195.00**
Z-MATCH II: Smith Chart program for RF Engineers - direct import from **ANALYSER III.**	**$375.00**	**£195.00**
We operate a no penalty upgrade policy. You can upgrade at any time to the professional version of a program just for the difference in price.	*US$ prices include Post and Packing.*	*Sterling £ prices exclude P&P and VAT*

For full information, Write, Phone or Fax:-

Number One Systems Ltd. 1

See us on STAND P29
EDS Wembley 5-7 Oct.

REF: EK, HARDING WAY, ST.IVES, HUNTINGDON, CAMBS, ENGLAND, PE17 4WR.
Telephone: 0480 461778 (7 lines) Fax: 0480 494042
International: +44 -480-461778, Fax:+44-480-494042 ACCESS, AMEX, MASTERCARD, VISA Welcome.

ELECTRONICS SCENE

E.A. Newman (b. 1918)

Edward Newman, a pioneer of digital computing, died last August. Shortly after graduating in physics just before the Second World War he joined the EMI Research Laboratories, where he worked with the great Arthur Blumlein.

After the war, he moved to the National Physical Laboratory where he worked with another great, Alan Turing, on developing ACE, one of the world's first electronic computers. It was there that he used his knowledge of television and radar to design digital circuits, which were then revolutionary, but made the project a success.

Later, he worked, under A.M. Uttley, on pattern recognition. From then on, he never lost his interest in understanding the human brain and correlating it with computer technology.

J.E. Dingman (b. 1901)

James Dingman, one of the pioneers of satellite communications, died last August. He was chief engineer of the American Telephone and Telegraph Company when, in 1962, he oversaw the first broadcast programme to be beamed into space and back again to earth via Telstar. This satellite (which is still in orbit) launched the modern era of telecommunications.

Many successors to Telstar were launched under Dingman's leadership after he had become Director of Comsat, the Communications Satellite Corporation.

£1000 AWARDS OFFERED TO WOMEN HND STUDENTS

Women undertaking a two-year full-time course or a block release course in electronic, electrical or allied engineering subjects leading to a Higher National Diploma are invited by the Caroline Haslett Memorial Trust (CHMT) to apply for Awards of £500 per annum.

The CHMT is administered by the Institution of Electronics and Electrical Engineers (IEEIE) and anyone interested in obtaining an award should apply now. Application forms are available from the Caroline Haslett Memorial Trust, IEEIE, Savoy Hill House, Savoy Hill, London WC2R 0BS. Telephone 071 36 3357.

AGENCY WARNS SUPPLIERS OF ILLEGAL VIDEOSENDERS

Videosenders that use radio to transmit the output from a video recorder to a television in another room without connecting wire are illegal!

The videosenders currently available work on the same channels as broadcast television and are likely to interfere with neighbouring reception. For that reason, the use of videosenders is not premitted and suppliers can be prosecuted.

Suppliers of videosenders have been convicted for inciting consumers to break the law. Heavy penalties amounting to several thousands of pounds have been imposed. Disclaimers such as "Not Licensed for Use in the UK" are no guarantee against convictions.

The Radiocommunications Agency intends to continue vigorous enforcement action against the suppliers of illegal radio products such as videosenders. Suppliers and advertisers are welcome to contact the Agency for further information or advice. Telephone 071 215 2247.

NETWORKING ACROSS ACADEMIA

The computer local area networks (LANS) of around 200 universities, polytechnics and research establishments in Britain have been linked for a decade by JANET, the Joint Academic Network. This system is now being upgraded with the latest high-speed fibre-optic technology, so that, in addition to just carrying messages, it will provide the academic community with an advanced communications infrastructure that will satisfy its needs through to the next century.

To be known as SuperJANET, the improved network is needed to support advanced learning and research activities. These require high-speed data, images and video communications in addition to voice. SuperJANET will augment, but not replace, the existing JANET network that was created in the early 1980s and which currently serves some 50 000 terminals and provides access to electronic mail services around the world, including the NSFNet (National Science Foundation Net) in the USA.

Higher performance overlay network.

SuperJANET will not change the way that research workers access remote databases and communicatie with their peers in all parts of the world on a routine basis via E-mail. However, it will provide a far higher performance overlay network that will roll out to an increasing number of establishments across the country. Then, as similar networks are developed in other countries, there will be the opportunity of extending the connectivity.

Dr Robert Cooper, who leads the project for the Science and Engineering Research Council/Universities Funding Council joint network team, believes that SuperJANET is unique in Europe – and almost so in the world. Explaining the new network's pioneering role, he added that it will be a test bed, because the academic world is very demanding and will employ the technology before it is widely used commercially.

Britain's Universities Funding Council (UFC) awarded the contract, worth £18 million over four years, to British Telecom (BT). The initial phase will link sites at Cambridge and Manchester Universities, Rutherford Appleton Laboratory, University College London, Imperial College London and Edinburgh University. During 1993-94, around 50 sites will be connected to the network with further ones being added subsequently, subject to additional funding.

Broadband technologies

The network design uses the latest broadband technologies and much of the connectivity will be based on BT's new Switched Multimegabit Data Service (SDMS). Synchronous Digital Hierarchy (SDH) will become the primary network technology which, together with new broadband switching technologies (distributed queue dual bus and asynchronous transfer mode), will provide for maximum interconnectivity.

Dr Alan Rudge, BT's managing director for development and procurement, with responsibility for all the company's technical research activity, stressed that the advanced broadband switching platform that will interlink sites is vital to industry as well as government and academia. "The SuperJANET contract allows BT to collaborate with universities on new applications which will, in due course, provide business with a competitive edge."

Dr Rudge stressed the need to promote the image that 'broadband is the norm'. He went on to say that BT proposes to participate in collaborative ventures with suppliers to deliver equipment. He further added that there is a need for a critical mass to engender confidence. Hence, BT expects that the availability of the network will provide the vital 'pump priming' function.

Visualization output.

The transmission to Imperial College in London of the visualization output of large-scale computational fluid dynamics calculations performed on the Cray YMP supercomputer at the Rutherford Appleton Laboratory is one engineering application proposed. As the vast amount of data generated by the application can only be absorbed by the user if it is presented as an image—often with colour and animation—superJANET will obviate the need for the researchers actually to be on the Rutherford site.

Similarly, the Medical Research Council (MRC) Cyclotron Unit at Hammersmith Hospital, in London, has several advanced facilities for producing brain images that are of interest to research workers at other sites. In the pilot project, brain images acquired at Hammersmith will be transferred to the Departments of Psychiatry at Edinburgh University and University College London (UCL) for analysis , and to the supercomputer centre at Edinburgh University for processing.

Interactive video

University College London has facilities to teach surgery via interactive video. Consequently, there is a proposal to set up a series of surgical demonstrations between UCL and the other centres which could support a range of interactive activities including surgical demonstrations from the operating theatre, clinical demonstration in the lecture theatre, discussions between surgical specialists, the co-operative preparation of video teaching material and exploration of ways of using existing courseware designed for self-directed learning in a distance learning environment.

This proposal hasa the support of the departments of surgery at St Mary's Hospital Medical School (Imperial College), London, and the universities of Edinburgh, Glasgow, Manchester and Cambridge.

Applications in the field of information services include library document distribution and an electrical journal testbed as well as a number of applications concerned with transferring large files rapidly from place to place. The former will aim to demonstrate document request and delivery over the network involving over seven universities (including two former polytechnics) with a view to eventually establishing a regular service between all universities. It will be more cost-effective than the existing inter-library loan arrangements which are slow and labour intensive.

SuperJANET will enable a large variety of tasks—encompassing a number of disciplines—to be undertaken that are currently being held back by lack of a suitable high-speed network. In addition, as each new application is successfully implemented, the benefits of superJANET will become more apparent to an even wider field.

Science and Engineering Research Council, Polaris House, Northstar Avenue, Swindon, England SN2 1ET.

MAPLIN ELECTRONICS NATIONAL KARAOKE CONTEST WON BY SARAH JANE HAVERS

Winner of the Maplin Electronics National Karaoke Contest sponsored by PMI (part of the EMI Music Empire) is Sarah Jane Havers, a back-stage chaperone from Taplow in Buckinghamshire. Runner-up is Miss Marianne Headington (aged 11) from Little Staughton, Bedfordshire. The judges included Sean King, Editor of *Video & Home Entertainment*, Martin Smith, Head of Programming Picture Music International, Robert Ball, Editor of *Electronics - The Maplin Magazine*, and pop singer Mark Khan. The photo shows Sarah Jane during the two-hour recording session at London's famour Abbey Road Studios, which was the first prize of the contest.

WORLD'S LARGEST QUADRATURE BOOSTER

The world's largest quadrature booster, used to help control the power flow in two parallel transmission lines has successfully completed works tests. The unit, rated at 2000 MVA, 400 kV, has been built at a cost of £5 million by Peebles Power Transformers in Edinburgh for use on Britain's national power grid.

Quadrature boosters are used in conjunction with existing autotransformers to control power flow. They inject a voltage in quadrature to the system phase voltage and variation is achieved by tap changing. Tap changing on the autotransformers injects a voltage that is in phase with the system voltage. Optimum sharing of megawatts and megavars in two parallel circuits can therefore be achieved by a combination of quadrature and in-phase voltage injection.

The largest quadrature booster previously built by Peebles was a 750 MVA, 275 kV unit made up of two core and winding assemblies housed in a single fabricated tank suitable for transportation to site.

The physical size of the latest unit, however, meant that each core and wind-

Produced and published by **ELEKTOR ELECTRONICS (Publishing)**

Editor/publisher: Len Seymour
Technical Editor: J. Buiting

Editorial & Administrative Offices:
P.O. Box 1414
DORCHESTER DT2 8YH
England
Telephone: (0305) 250 995 (*National*)
or +44 305 250 995 (*International*)
Fax: (0305) 250 996 (*National*)
or +44 305 250 996 (*International*)

U.K. Advertising Office:
3 Crescent Terrace
CHELTENHAM GL50 3PE
Telephone: (0242) 510 760
Fax: (0242) 226 626

International Advertising Office:
Elektuur BV
P.O. Box 75
6190 AB BEEK
The Netherlands
Telephone: +31 46 38 94 44
Fax: +31 46 37 01 61

Subscriptions:
World Wide Subscription Service Ltd.
Unit 4, Gibbs Reed Farm
Pashley Road
TICEHURST TN5 7HE
Telephone: (0580) 200 657 (*National*)
or +44 580 200 657 (*International*)
Fax: (0580) 200 616 (*National*)
or +44 580 200 616 (*International*)

Head Office:
P.O. Box 75
6190 AB BEEK
The Netherlands
Telephone: +31 46 38 94 44
Telex: 56617 (elekt nl)
Fax: +31 46 37 01 61
Managing Director: M.M.J. Landman

Distribution:
SEYMOUR
1270 London Road
LONDON SW16 4DH

Printed in the Netherlands by NDB, Zoeterwoude

Overseas editions:
FRANCE
Elektor sarl
Les Trois Tilleuls
B.P. 59; 59850 NIEPPE
Editor: G.C.P. Raedersdorf

GERMANY
Elektor Verlag GmbH
Süsterfeld Straße 25
5100 AACHEN
Editor: E.J.A. Krempelsauer

GREECE
Elektor EPE
Kariskaki 14
16673 Voula—ATHENA
Editor: E. Xanthoulis

HUNGARY
Elektor Elektronikai folyórat
1015 Budapest
Batthyány u. 13
Editor: Lakatos András

INDIA
Elektor Electronics PVT Ltd
Chhotani Building
52C, Proctor Road, Grant Road (E)
BOMBAY 400 007
Editor: C.R. Chandarana

ISRAEL
Elektorcal
P O Box 41096
TEL AVIV 61410
Publisher: M. Avraham

NETHERLANDS
Elektuur BV
Peter Treckpoelstraat 2–4
6191 VK BEEK
Editor: P.E.L. Kersemakers

POLAND
Elektor Elektronik
02–777 Warszawa 130
Skrytka Pocztowa 271
Editor: W. Marciniak

PORTUGAL
Ferreira & Bento Lda.
R.D. Estefâni, 32-1°
1000 LISBOA
Editor: F. Ferreira de Almeida

SPAIN
Resistor Electronica Aplicada
Calle Maudes 15 Entlo C.
28003 MADRID
Editor: Agustin Gonzales Buelta

SWEDEN
Electronic Press AB
Box 5505
14105 HUDDINGE
Editor: Bill Cedrum

Books from Elektor Electronics (Publishing)

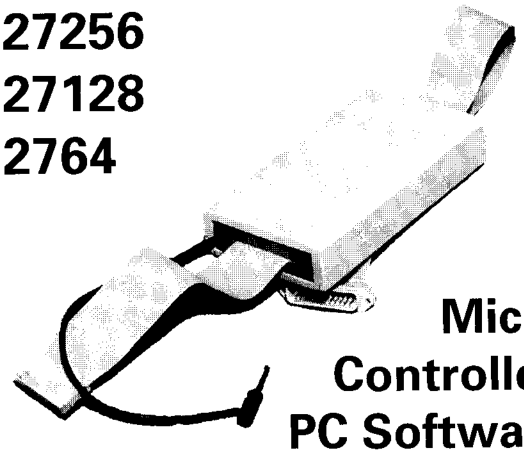
The following books are currently available:

301 Circuits	£9·95	$14.50
302 Circuits	£9·95	$14.50
303 Circuits	£10·95	$17.90
304 Circuits	£12·95	$23.95
Microprocessor Data Book	£10·95	$19.90
Data Sheet Book 2	£9·95	$18.50
Data Book 3: Peripheral Chips	£10·95	$19.95
Data Book 4: Peripheral Chips	£10·95	$19.95
Data Book 5: Application Notes	£10·95	$19.95

The books may be obtained from bookshops*, Old Colony Sound Lab (USA and Canadian readers only—for address, see order form on p. 79) or direct from our Dorchester office (private customers only*) on the order form on page 79.

* Orders other than from private customers, for instance, bookshops, schools, colleges, should be sent to

Gazelle Book Services Ltd
Falcon House
Queen Square
Lancaster LA1 1RN
England
Telephone (0524) 68765; Fax (0524) 63232



EPROM EMULATOR
32K x 8 Non Vol (EEPROM)
27256
27128
2764
Micro Controlled PC Software Included (Com1/2). Int/Mot Hex Download. Modify Memory. Powered from Target SKT
£150 + Car. + VAT
ZE SYSTEMS Ltd
Tel: 0280 850521 Fax: 0280 850434

ing assembly had to be housed in a separate tank. The shipping mass of each assembly at 240 tonnes was in fact greater than the combined shipping mass of the 750 MVA unit.

Following the successful completion of testing, the giant booster has been shipped from Granton Harbour on the Firth of Forth by RoRo (roll-on, roll-off) ship to the port of Goole en route to the National Grid substation at Stockbridge, near Sheffield.

Peebles Power Transformers Ltd, East Pilton, Edinburgh, Scotland EH5 2XT.

APPLE CHOOSES INTEL FLASH STORAGE CARDS FOR NEWTON MESSAGEPAD

Intel Corporation is providing Apple Computer Inc. with 2 Mbyte flash storage cards packaged in credit-card size for the Newton* Messagepad*.

The many benefits of flash are allowing mobile system designers to make the vision of hand-held computing devices a reality. In designing Newton technology, Apple was able to go beyond the disk drive paradigm. Instead of retrofitting flash to behave like a drive, they looked at the unique benefits of flash and designed a better storage system for their customers.

* Newton and Messagepad are trademarks of Apple Computer Inc.

Intel Corporation (UK) Ltd, Pipers Way, Swindon, England SN3 1RJ.

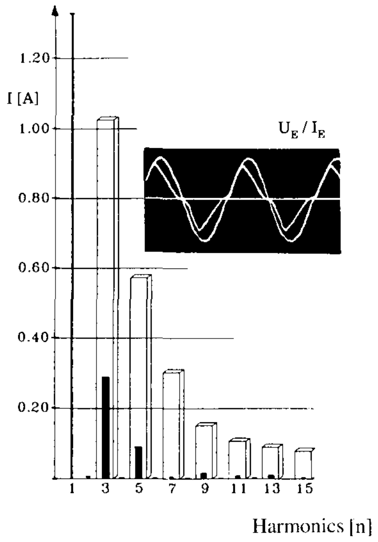
MEGAVISION – A CHIP SET FOR TELEVISION AND MULTIMEDIA

As a successor to its award-winning 'Featurebox 88' chip set, Siemens has introduced a complete system of integrated circuits that not only offers flicker-free television, but can also be used in studio and multimedia applications. Picture quality has been enhanced even beyond the levels offered by 100 Hz technology. New functions have also been implemeted. Changing over to submicron technology has allowed a higher level of integration and this in turn provides cost benefits. The modular component principle starts with picture processing for 16:9 screens and, with the most sophisticated configurations, includes noise reduction, picture-in-freeze frame, freeze frame in picture, nine-element picture with tuner scanning and full-frame mode without line flicker.

LOW-HARMONIC SWITCHED-MODE POWER SUPPLIES

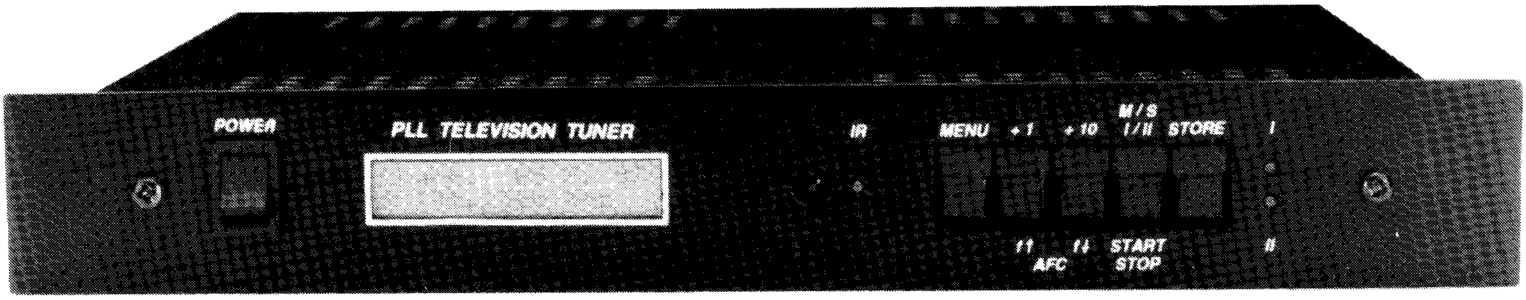
To reduce the harmonic content of switched-mode power supplies for TV sets and monitors, Siemens has developed a set of control chips that conform to tomorrow's standards today. The chips, coded TDA 4061 and TDA 4605, 4605-2, 4605-3, are designed for different power consumptions. Their use produces a sinusoidal current input for the flyback power supplies.

Siemens AG, LZF Infoservice, Postfach 23 48, D-90713, Munich, Germany.



An harmonics analysis based on EN60555 shows the excellent values for switched-mode power supplies that can be obtained with the TDA4605 control chips (black bars). The columns show the permissible limits for the operational data applying here: 230 V a.c., 50 Hz, 1.36 A current input (fundamental), i.e., a power consumption of 300 W. The oscillogram shows the quasi-sinusoidal relationship between the input voltage and input current.

VHF/UHF TELEVISION TUNER (PART 1)



Together with a suitable colour monitor, the television tuner described here forms a complete television set. Microprocessor controlled, menu-driven, with digital tuning, a small LCD text screen, optional infra-red remote control, and memory capacity for up to 100 preset stations, the tuner is ideal for TV DXing and interfacing to a computer system via a video digitizer. The unit offers full coverage of the VHF and UHF TV bands, and apart from the normal mono sound channel, analogue stereo sound as used in some countries on the European continent is also provided.

Design by W. Sevenheck

THE block diagram of the TV tuner is given in **Fig. 1**. The most important sections are the power supply, the (ready-made) VHF/UHF tuner module, and the intermediate frequency (IF) circuit plus sound decoder. A microprocessor core based on a 8751 controller arranges, among others, the control of a two-line LCD text display, a small keyboard, and the tuning of the tuner module. The serial I^2C bus is used for the communication between the microcontroller and a number of other ICs in the circuit. The digital signals needed for this communication are generated by the microcontroller itself. In addition, the 8751 also decodes and processes the digital RC5 codes received from an RC5 compatible infra-red remote control.

The TV tuner supplies a colour-video-blanking-synchronization (CVBS, or simply 'composite video'), output signal into a standard load impedance of 75 Ω.

Circuit description

The circuit diagram in **Fig. 2** shows the VHF/UHF tuner module, the sound and vision decoders, and the power supply. Nearly all the 'work' in the circuit is done by three powerful integrated circuits from Philips Semiconductors. All three, the TDA3842 multistandard video IF processor, the TDA3857 sound IF processor, and the TDA8415 sound processor, appear in recommended application circuits as found in the Philips datasheets. Two surface-acoustic wave (SAW) filters from Siemens are used to minimize cross-interference between sound and vision. Both filters pass the down-converted 38.9-MHz reference carrier. Filter Fl_1 also passes the sound component, while Fl_2 does the same with the vision component. In both cases, the 38.9-MHz signal is needed as a reference in the decoding operation. A simple analogue-to-digital converter (ADC) based on a resistor ladder network and an LM339 opamp (IC_4) converts the AFC (automatic frequency control) signal supplied by IC_3 into four logic levels that are accepted by the microcontroller, which uses the 4-bit code to ensure the best possible tuning of the tuner module.

The tuner module, a Type UV816PLL from Philips Components, requires three supply voltages: 5 V, 12 V and 33 V. The unit gives full coverage of the VHF-1 (channels E2 to C; 48.25 MHz to 82.25 MHz), VHF-3 (175.25 MHz to 224.25 MHz) and UHF (channels E21 to E69; 471.25 MHz to 855.25 MHz) TV bands. It should be noted that the VHF-1 and VHF-3 bands are no longer used for television in the UK. They are still of interest, however, because of the many signals that can be received (under favourable propagation conditions) from overseas TV stations transmitting in these bands.

Tuning is accomplished with the aid of (serial) digital commands applied to the module via its I^2C bus connections, SDA and SCL. The intermediate frequency signal is available on the two IF outputs, pins 16 and 17. The UV816PLL is provided with a digital programmable phase-locked loop (PLL) tuning system. This enables tuning with a 62.5-kHz raster at crystal accuracy. Apart from tuning, band switching is also carried out via the I^2C bus. The tuner's AGC input is driven by the TDA3842 video processor. The video (vision) and audio (sound) decoder circuits are connected in parallel to the tuner's IF outputs.

Vision channel

After the sound information has been eliminated by SAW filter Fl_2, the IF signal is applied to IC_3, a Type TDA3842 multi-standard video IF amplifier/demodulator. The internal structure of this IC is given in **Fig. 3**. Glancing back at the circuit diagram in Fig. 2, it is easily seen that the TDA3842 is used in its standard application circuit. However, the switch marked 'video-off' is not implemented, while the video switch at pin 9 is available as a connection (solder spot) only, which allows the AGC to be driven by negative (B/G) or positive (L) modulation of the sync signal. The B/G option is the default. The L option is only used with TV systems other than PAL, such as

SECAM.

In the following descriptions, frequencies that apply to the UK television standard (CCIR System I) are given in brackets.

A 5.5 MHz (6.0 MHz) sound subcarrier trap is connected between pins 13 and 14 of the TDA3842. The parallel *LC* tuned circuit required for the video demodulator is connected to pins 10 and 11. The demodulator supplies the AFC (automatic frequency control) via a 90° phase shift. The preset potentiometer connected to pin 2 determines the operating point of the AGC. If the signal level is too low, transistor T3 arranges for the mute circuit to be actuated. The audio channel in the TDA8415 (IC2) is then cut off, so that the loudspeaker does not produce noise. The sound channel is opened again when a sufficiently strong signal is received.

The BC547B transistor at the video output of the TDA3842 buffers the video signal, and ensures an output impedance of about 75 Ω. Capacitors C31 and C32 block the d.c. component in the output signal.

The AFC output signal produced by the TDA3842 is fed to the above mentioned 4-level comparator circuit around IC4. The resultant 4-bit code supplied by the four comparator outputs is used by the microcontroller to fine-tune the receiver.

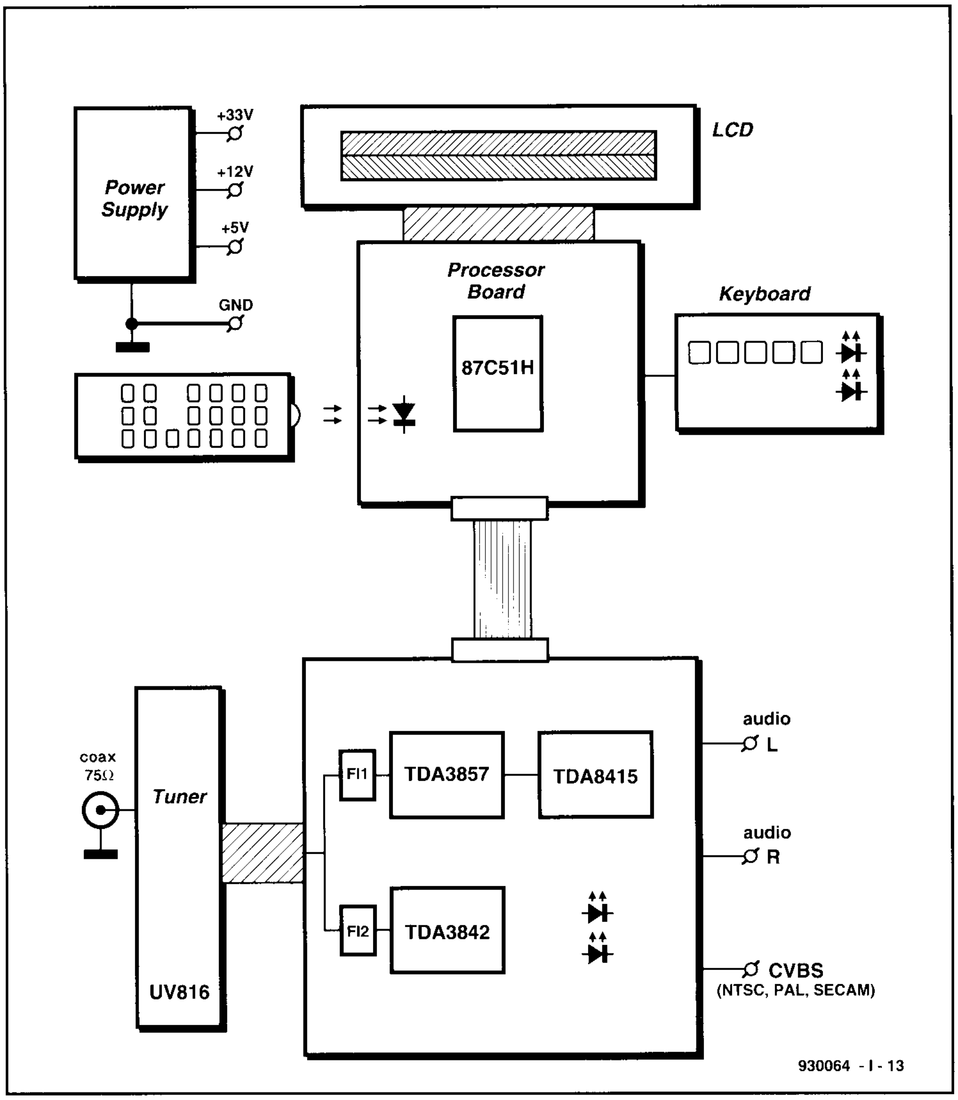


Fig. 1. Block diagram of the VHF/UHF TV tuner. A microcontroller is used to control the analogue sections, while an LCD is useful for operating the tuner.

Sound channel

The sound channel is based on two further ICs from Philips Semiconductors' family of high-integration TV/video building blocks. These ICs are the TDA3857 IF amplifier with two FM demodulators, and the TDA8415 sound processor for two-language sound, with integrated filters and I^{2}C bus control. To begin with, the video component is suppressed by SAW filter Fl1, while the 38.9 MHz reference carrier and the sound component are passed. Next, the balanced IF signal is applied to IC1.

The internal organisation of the TDA3857 is given in **Fig. 4**. First, the level of the IF signal is 'stabilized' with the aid of an automatic gain control (AGC). The speed of this control is determined by capacitor C1, which is connected to pin 2. The sound intercarrier is restored on the basis of the input signal, while any residual AM signals are suppressed. The two components produced by the mixer, 5.5 MHz (6.0 MHz) and 5.74 MHz, are separated by appropriate external ceramic filters, X6 and X7, and then processed separately in the IC. The 5.5 MHz (6.0 MHz) subcarrier supplies the main sound channel as produced by any mono TV set. The second limiter/demodulator in the TDA3857 is tuned to a narrow band around 5.74 MHz, which contains information for stereo or two-language broadcasts. Note that this type of analogue stereo sound with TV broadcasts is used in some European countries only, including Germany and Holland. It is not used in the UK, where stereo TV sound is digital and based on the NICAM-728 standard. Two tuned circuits, X2 and X3, are used to demodulate the sound signals at 5.74 MHz and 5.5 MHz (6.0 MHz) respectively. In the absence of a 5.74-MHz component, the associated sound channel is automatically muted, leaving the main sound channel to be heard only. The two audio signals are output via pins 6 and 7, and fed to the audio processor, IC2. Preset P1 is included in the circuit to allow the level of the two audio channels — 5.5 MHz (6.0 MHz) and 5.74 MHz — to be made equal. This is necessary to ensure the best possible channel separation with stereo broadcasts.

The sound processor, IC2, is a TDA8415. This IC has been developed for stereo or two-language sound in TV sets and video recorders. As shown in the block diagram in **Fig. 5**, audio signals are applied to the two inputs of this processor: '(L+R)/2' or language 'A' goes to input AF1, and 'R' or language 'B' to input AF2. In this notation, 'L' is the left-hand audio channel in a stereo broadcast, and 'R' the right-hand audio channel. A pilot tone modulated 50% AM on a subcarrier at 54.6875 KHz enables the sound processor to distinguish between stereo and two-language broadcasts. The pilot tone is contained in the signal for the second channel (E2) and has a frequency of 117.4 Hz for stereo broadcasts, or 274.1 Hz for two-language broadcasts. Depending on the mode of the sound processor (mono, stereo or two-language), LED D1 and/or D2 is controlled by IC outputs C1 and C2 via two buffer transistors. The sound processor IC itself is controlled via the SCL and SDA lines that form the I^{2}C bus. Special commands on this bus allow the processor's signal inputs to be selected, and the muting to be actuated. The timing signals

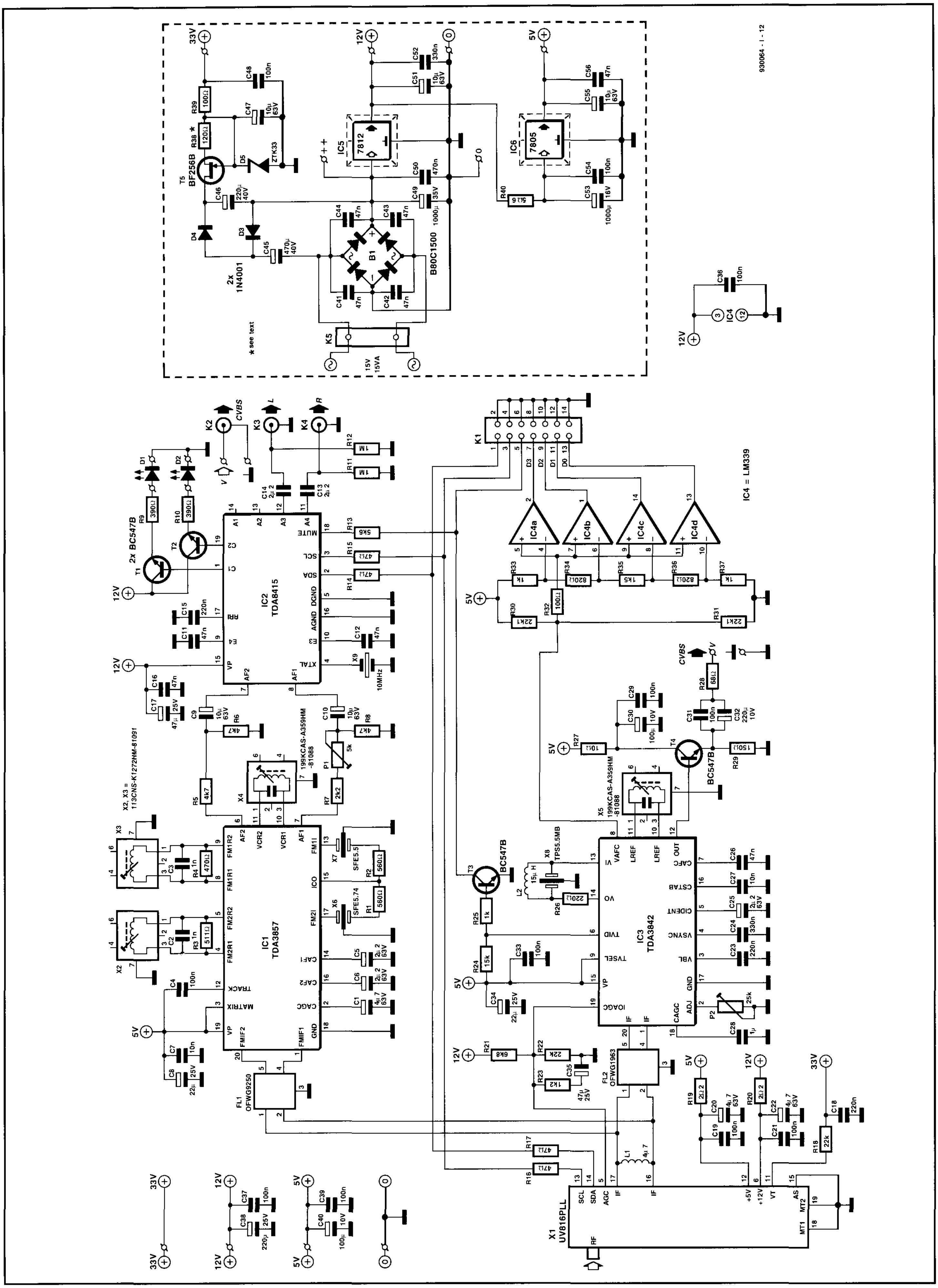


Fig. 2. Circuit diagram of the analogue section and the power supply. The circuit remains relatively simple thanks to the use of three dedicated integrated circuits developed for the modern TV industry.

required for these operations are derived from a 10-MHz quartz crystal, X9, which is connected to an on-chip oscillator. The audio output signals are fed out of the circuit via capacitors C13 and C14. The additional audio inputs, E3 and E4, and the additional audio outputs, A3 and A4, are not used in the present circuit.

Power supply

All supply voltages required for the VHF/UHF TV tuner are derived from a single 15-V, 15-VA mains transformer, whose secondary winding is connected to K5. A voltage doubler, D3-D4-C45-C46, turns the 15 V a.c. into about 35 V d.c., which is stepped down to a regulated voltage of 33 V by a zener diode, D5, connected to a current source, T5-R38. The regulated and temperature-compensated 33-V supply voltage is applied to the UV816PLL TV tuner module.

The direct voltage of about 18 V across C49 is stepped down to 12 V by regulator IC5. This also powers the second regulator, IC6, which provides the 5-V supply rail. Resistor R40 is connected between the output of IC5 and the input of IC6 to reduce the dissipation of the 5-V regulator.

Traffic control: an 8751

The remainder of the circuit is given in **Fig. 6**. All control activities are assumed by a single microcontroller Type 8751, which comes ready-programmed through our Readers Services. The circuit around the microcontroller has no surprises. The power-up reset network is formed by R2-C2. The 10-MHz clock signal is generated with the aid of crystal X1. Two resistor arrays, R6 and R7, provide the necessary pull-up resistors on a number of I/O lines. The two-line LC display is connected to boxheader K2, which supplies all the necessary drive signals, including the contrast voltage which is set with P1. Jumper JP1 is used to actuate the background light on some types of display unit.

Connector K1 forms the link with the rest of the circuit. Apart from the SDA and SCL signals, this bus also carries the 4-bit AFC information supplied by IC4, and the mute signal, ID.

As already mentioned, the TV tuner has a capacity of 100 preset stations. Since the 8751 does not have enough internal memory for this purpose, external memory has been added in the form of an I^2C compatible EEPROM with a capacity of 256 bytes. The EEPROM, a Type PCF8582A, is capable of retaining data without a backup voltage. An *RC* network, R4-C8, is connected to the PTC input to make sure

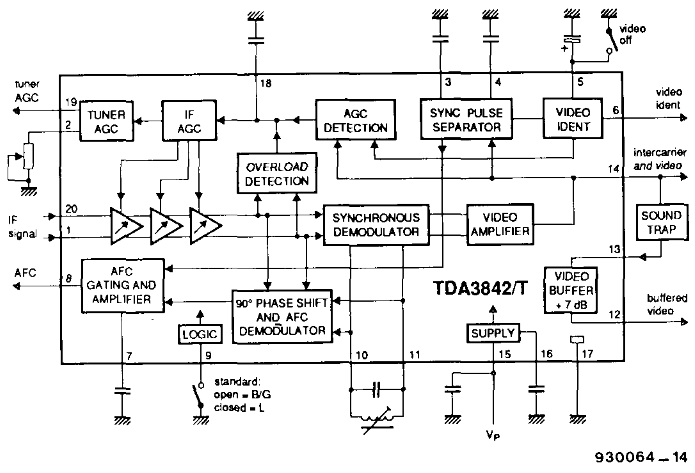


Fig. 3. Block diagram and typical surroundings of the TDA3842 video demodulator (courtesy Philips Semiconductors).

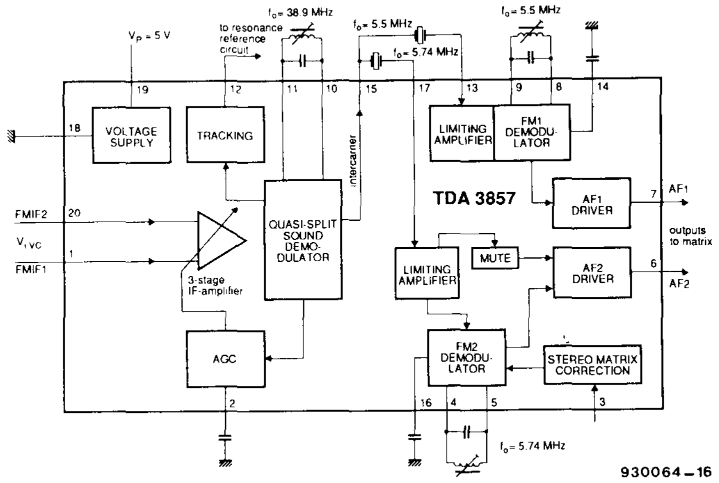


Fig. 4. Block diagram of the TDA3857 sound demodulator (courtesy Philips Semiconductors).

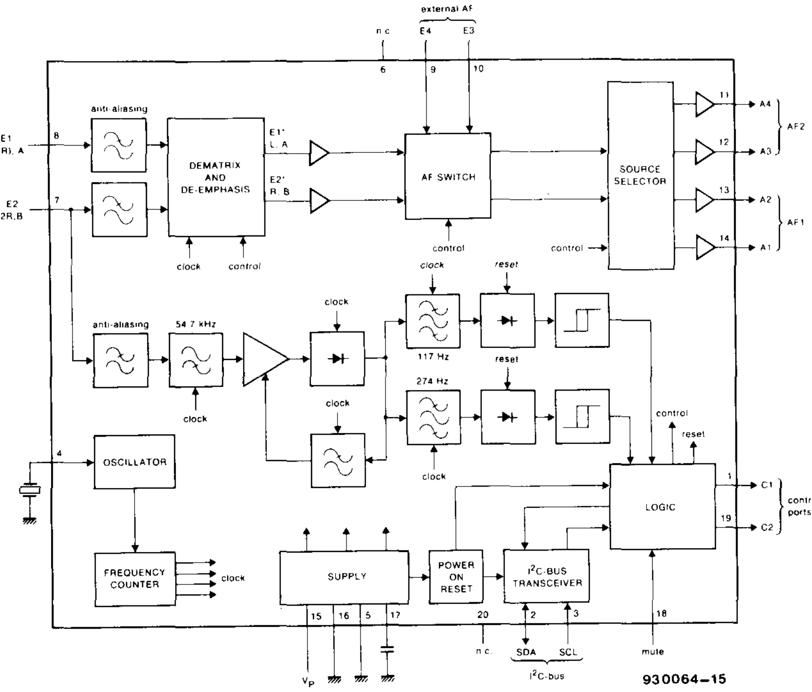


Fig. 5. Block diagram of the TDA8415 audio processor for TVs (courtesy Philips Semiconductors).

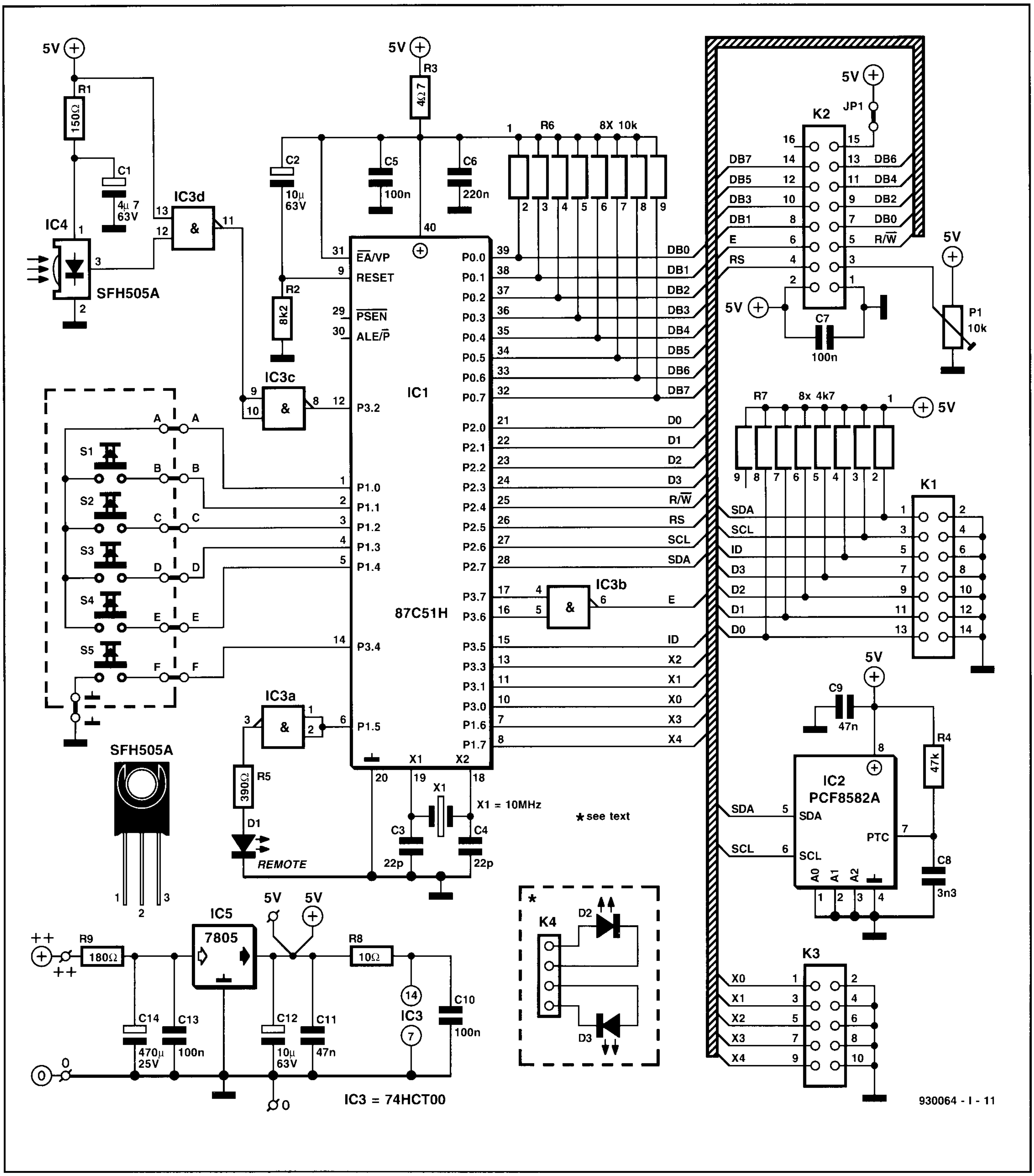


Fig. 6. Circuit diagram of the digital control based on an 87C51 microcontroller from Intel. The preset stations are stored in an EEPROM, IC2.

that the timing of the read/write cycle in the memory is correct.

The local keyboard on the tuner consists of five press-keys which are connected directly to microcontroller port lines.

The infra-red receiver is formed by IC4, an SFH505A module from Siemens. The pulses supplied by the IR receiver reach the microcontroller via inverters IC3c and IC3d. The microcontroller is programmed to respond to codes transmitted by RC5 compatible (Philips standard) remote control units, and causes LED D1 to flash while a valid IR signal is being received.

Finally, the processor board has its own 5-V regulator to improve the separation between the digital and analogue sections of the tuner. An additional advantage of the separate supply is that the processor board may be used for other applications. In this regard it is useful to mention connector K3, which carries the non-used I/O lines.

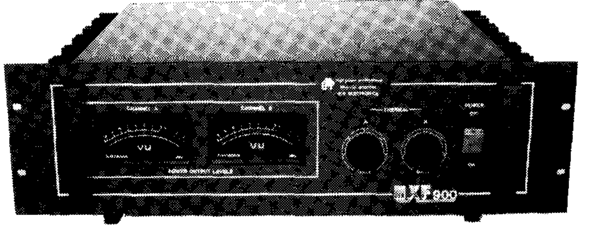
Next month's second and final instalment of this article will discuss the construction of the printed circuit boards, and the enclosure in which the tuner is fitted. Also, the operation of the unit will be discussed extensively. ❑

POWER AMPLIFIER MODULES-TURNTABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

★ PRICES INCLUDE V.A.T. ★ PROMPT DELIVERIES ★ FRIENDLY SERVICE ★ LARGE (A4) S.A.E., 60p STAMPED FOR CATALOGUE ★

OMP MOS-FET POWER AMPLIFIERS
HIGH POWER, TWO CHANNEL 19 INCH RACK

THOUSANDS PURCHASED BY PROFESSIONAL USERS



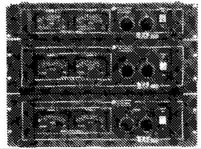
THE RENOWNED MXF SERIES OF POWER AMPLIFIERS

FOUR MODELS:- **MXF200** (100W + 100W) **MXF400** (200W + 200W) **MXF600** (300W + 300W) **MXF900** (450W + 450W)

ALL POWER RATINGS R.M.S. INTO 4 OHMS, BOTH CHANNELS DRIVEN

FEATURES: ★Independent power supplies with two toroidal transformers ★ Twin L.E.D. Vu meters ★ Level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low *distortion* ★ Aluminium cases ★ MXF600 & MXF900 fan cooled with D.C. loudspeaker and thermal protection.

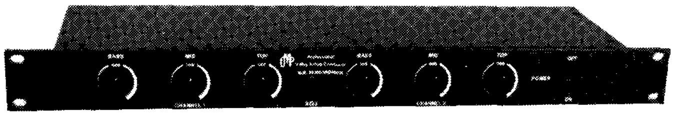
USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.



SIZES:- MXF200 **W19″xH3½″ (2U)xD11″**
MXF400 **W19″xH5¼″ (3U)xD12″**
MXF600 **W19″xH5¼″ (3U)xD13″**
MXF900 **W19″xH5¼″ (3U)xD14¾″**

PRICES:-MXF200 £175.00 MXF400 £233.85
MXF600 £329.00 MXF900 £449.15
SPECIALIST CARRIER DEL. £12.50 EACH

OMP XO3 STEREO 3-WAY ACTIVE CROSS-OVER

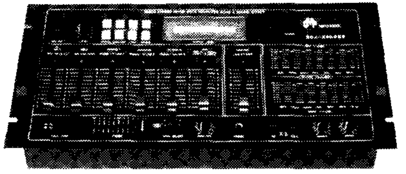


Advanced 3-Way Stereo Active Cross-Over, housed in a 19" x 1U case. Each channel has three level controls: bass, mid & top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 250/500/800Hz, Mid-Top 1.8/3/5KHz, all at 24dB per octave. Bass invert switches on each bass channel. Nominal 775mV input/output. Fully compatible with OMP rack amplifier and modules.

Price £117.44 + £5.00 P&P

STEREO DISCO MIXER SDJ3400SE ★ ECHO & SOUND EFFECTS★

STEREO DISCO MIXER with 2 x 7 band L & R graphic equalisers with bar graph LED *Vu meters.* **MANY OUTSTANDING FEATURES:- including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor. 8 Sound Effects. Useful combination of the following inputs:- 3 turntables (mag), 3 mics, 5 Line for CD, Tape, Video etc.**

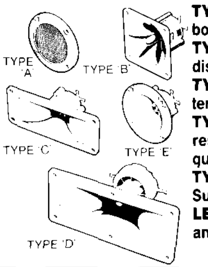


Price £144.99 + £5.00 P&P

SIZE: 482 x 240 x 120mm

PIEZO ELECTRIC TWEETERS - MOTOROLA

Join the Piezo revolution! The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover **is not** required these units can be added to existing speaker systems of up to 100 watts (more if two are put in series. **FREE EXPLANATORY LEAFLETS ARE SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN1036A) 3″ round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi apeakers. **Price £4.90 + 50p P&P.**

TYPE 'B' (KSN1005A) 3½″ super horn for general purpose speakers, disco and P.A. systems etc. **Price £5.99 + 50p P&P.**

TYPE 'C' (KSN1016A) 2″x5″ *wide dispersion horn for quality Hi-Fi sys*tems and quality discos etc. **Price £6.99 + 50p P&P.**

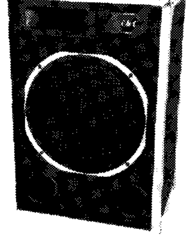
TYPE 'D' (KSN1025A) 2″x6″ wide dispersion horn. Upper frequency response retained extending down to mid-range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. **Price £9.99 + 50p P&P.**

TYPE 'E' (KSN1038A) 3¾″ horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. **Price £5.99 + 50p P&P.**

LEVEL CONTROL Combines, on a recessed mounting plate, level control and cabinet input jack socket. 85x85mm. **Price £4.10 + 50p P&P.**

ibl FLIGHT CASED LOUDSPEAKERS

A new range of quality loudspeakers, designed to take advantage of the latest speaker technology and enclosure designs. Both models utilize studio quality 12" cast aluminium loudspeakers with factory fitted grilles, wide dispersion constant directivity horns, extruded aluminium corner protection and steel ball corners, complimented with heavy duty black covering. The enclosures are fitted as standard with top hats for optional loudspeaker stands.



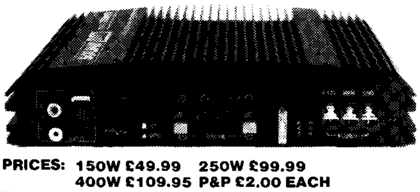
POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET
FREQUENCY RESPONSE FULL RANGE 45Hz - 20KHz

***ibl* FC 12-100WATTS (100dB) PRICE £159.00 PER PAIR**
***ibl* FC 12-200WATTS (100dB) PRICE £175.00 PER PAIR**

SPECIALIST CARRIER DEL. £12.50 PER PAIR

OPTIONAL STANDS PRICE PER PAIR £49.00
Delivery £6.00 per pair

IN-CAR STEREO BOOSTER AMPS



PRICES: 150W £49.99 250W £99.99
400W £109.95 P&P £2.00 EACH

***THREE SUPERB HIGH POWER* CAR STEREO BOOSTER AMPLIFIERS**

150 WATTS (75 + 75) Stereo, 150W Bridged Mono
250 WATTS (125 + 125) Stereo, 250W Bridged Mono
400 WATTS (200 + 200) Stereo, 400W Bridged Mono

ALL POWERS INTO 4 OHMS

Features:
★ Stereo, bridgable mono ★ Choice of high & low level inputs ★ L & R level controls ★ Remote on-off ★ Speaker & thermal protection.

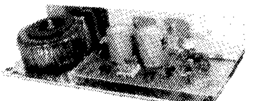
POSTAL CHARGES PER ORDER £1.00 MINIMUM. OFFICIAL ORDERS FROM SCHOOLS, COLLEGES, GOVT. BODIES, PLCs ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER. VISA AND ACCESS ACCEPTED BY POST, PHONE OR FAX.

OMP MOS-FET POWER AMPLIFIER MODULES

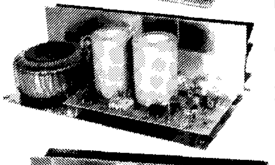
SUPPLIED READY BUILT AND TESTED.

These modules now enjoy a world-wide reputation for quality, *reliability and performance at a realistic price. Four* models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

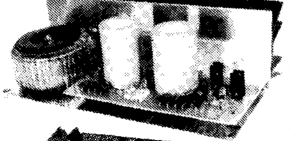
THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS



OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB. *Size 300 x 123 x 60mm.*
PRICE £40.85 + £3.50 P&P

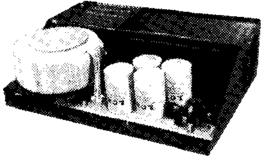


OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, *frequency response 1Hz - 100KHz* -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 155 x 100mm.
PRICE £64.35 + £4.00 P&P



OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
PRICE £81.75 + £5.00 P&P

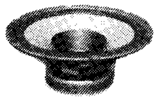
OMP/MF 450 Mos-Fet *Output power 450* watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE £132.85 + £5.00 P&P



OMP/MF 1000 Mos-Fet Output power 1000 watts *R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms*, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE £259.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

LOUDSPEAKERS



LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE (A4) S.A.E. (60p STAMPED) FOR COMPLETE LIST.

McKenzie and Fane Loudspeakers are also available.

EMINENCE:- INSTRUMENTS, P.A., DISCO, ETC

ALL EMINENCE UNITS 8 OHMS IMPEDANCE

8″ 100 WATT R.M.S. ME8-100 GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID, DISCO.
RES. FREQ. 72Hz, FREQ. RESP. TO 4KHz, SENS 97dB. **PRICE £32.71 + £2.00 P&P**

10″ 100 WATT R.M.S. ME10-100 GUITAR, VOCAL, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 71Hz, FREQ. RESP. TO 7KHz, SENS97dB. **PRICE £33.74 + £2.50 P&P**

10″ 200 WATT R.M.S. ME10-200 GUITAR, KEYB'D, DISCO, VOCAL, EXCELLENT HIGH POWER MID.
RES. FREQ. 65Hz, FREQ. RESP. TO 3.5KHz, SENS 99dB. **PRICE £43.47 + £2.50 P&P**

12″ 100 WATT R.M.S. ME12-100LE GEN. PURPOSE, LEAD GUITAR, DISCO, STAGE MONITOR.
RES.FREQ. 49Hz, FREQ. RESP. TO 6KHz, SENS 100dB. **PRICE £35.64 + £3.50 P&P**

12″ 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE MONITOR. RES. FREQ 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. **PRICE £36.67 + £3.50 P&P**

12″ 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID.
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. **PRICE £46.71 + £3.50 P&P**

12″ 300 WATT R.M.S ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC.
RES. FREQ. 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB. **PRICE £70.19 + £3.50 P&P**

15″ 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR.
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB. ***PRICE £50.72 + £4.00 P&P***

15″ 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR.
RES. FREQ. 39Hz, FREQ. RESP. TO 3KHz, SENS 103dB. **PRICE £73.34 + £4.00 P&P**

EARBENDERS:- HI-FI, STUDIO, IN-CAR, ETC

ALL EARBENDER UNITS 8 OHMS (Except EB8-50 & EB10-50 which are dual impedance tapped @ 4 & 8 ohm)

BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND

8″ 50watt EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz SENS 97dB. **PRICE £8.90 + £2.00 P&P**

10″ 50WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB. **PRICE £13.65 + £2.50 P&P**

10″ 100WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB. **PRICE £30.39 + £3.50 P&P**

12″ 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB. **PRICE £42.12 + £3.50 P&P**

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

5¼″ 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB. **PRICE £9.99 + £1.50 P&P**

6½″ 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB. **PRICE £10.99 + 1.50 P&P**

8″ 60WATT EB8-60TC *(TWIN CONE) HI-FI, MILTI-ARRAY DISCO ETC.*
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB. **PRICE £12.99 + £1.50 P&P**

10″ 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC.
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB. **PRICE £16.49 + £2.00 P&P**

TRANSMITTER HOBBY KITS

PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS

3W TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 x 123mm, SUPPLY 12V @ 0.5AMP.
PRICE £14.85 + £1.00 P&P

FM MICRO TRANSMITTER 100-108MHz, VARICAP TUNED, COMPLETE WITH VERY SENS FET MIC, RANGE 100-300m, SIZE 56 x 46mm, SUPPLY 9V BATTERY.
PRICE £8.80 + £1.00 P&P

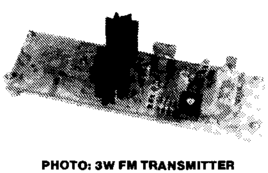


PHOTO: 3W FM TRANSMITTER

B.K. ELECTRONICS

UNITS 1 & 5 COMET WAY, SOUTHEND-ON-SEA,
ESSEX. SS2 6TR.
Tel.: 0702 - 527572 Fax.: 0702 - 420243

VIEWCOM

TEL 081-471 9338 TLX 929709 VICOM G FAX 081-552 0946

DIGITAL INTEGRATED CIRCUIT SPECIALIST

4000 SERIES

4000B	0.12
4000UB	0.14
4001A	0.12
4001B	0.12
4001UB	0.14
4002B	0.12
4006B	0.30
4007UB	0.14
4008B	0.31
4009AE	0.18
4009UB	0.22
4010B	0.22
4011B	0.14
4011UB	0.14
4012AE	0.12
4012B	0.14
4013B	0.17
4014B	0.30
4015B	0.30
4016B	0.18
4017B	0.26
4018B	0.28
4019B	0.20
4020AE	0.29
4020B	0.30
4021B	0.31
4022B	0.32
4023B	0.14
4023UB	0.17
4024AE	0.21
4024B	0.21
4025B	0.14
4026B	0.38
4027B	0.18
4028B	0.28
4029B	0.27
4030B	0.16
4031B	0.80
4032B	0.54
4033B	0.54
4034B	1.10
4035B	0.30
4036B	1.98
4037B	0.98
4038B	0.60
4039B	2.48
4040B	0.29
4041B	0.32
4042B	0.22
4043B	0.28
4044B	0.30
4045B	0.72
4046B	0.32
4047B	0.27
4048B	0.32
4049B	0.20
4049UB	0.20
4050B	0.20
4051B	0.25
4052B	0.25
4053B	0.25
4054B	0.52
4055B	0.48
4056B	0.36
4059B	2.98
4060B	0.30
4063B	0.28
4066B	0.22
4067B	1.42
4068B	0.14
4069UB	0.16
4070B	0.16
4071B	0.16
4072B	0.16
4073B	0.16
4075B	0.16
4076B	0.32
4077B	0.16
4078B	0.16
4081B	0.13
4082B	0.16
4085B	0.32
4086B	0.29
4089B	0.54
4093B	0.14
4094B	0.30
4095B	0.54
4096B	0.85
4097B	1.20
4098B	0.31
4099B	0.38
4104P	0.78
4106B	0.58
4160B	0.65
4161B	0.65
4163B	0.98
4174B	0.98
4175B	0.88
4194B	1.10
4409P	8.50
4410P	12.65
4411P	16.60
4412F	POA
4412FL	POA
4412VP	POA
4416P	POA
4419P	POA
4429PB	5.60
4433P	15.85
4443P	8.90
4447P	9.78
4468P	8.75
4469P	24.10
4489P	12.85
4490P	3.90
4490L	9.80
4495P	4.82
4497P	10.45
4499P	4.80
4500B	14.96
4501UB	0.27
4502B	0.34
4503B	0.30
4504B	1.37
4505B	3.40
4506U	0.88
4508B	0.72
4510B	0.26
4511B	0.32
4512B	0.30
4513B	2.60
4514B	0.72
4515B	0.72
4516B	0.30
4517B	0.92
4518B	0.27
4519B	0.28
4520B	0.28
4521B	0.60
4522B	0.72
4526B	0.40
4527B	0.38
4528B	0.40
4529B	0.44
4530B	1.48
4531B	0.88
4532B	0.44
4534B	3.98
4536B	0.98
4538B	0.44
4539B	0.62
4541B	0.32
4543B	0.44
4544B	1.62
4547B	1.78
4549B	POA
4551B	1.36
4553B	1.82
4554B	4.62
4555B	0.32
4556B	0.38
4557B	1.88
4558B	1.68
4560B	1.16
4561B	1.34
4562B	3.96
4566B	1.60
4568B	3.98
4569B	2.34
4572UB	0.30
4573P	POA
4580B	6.80
4581B	2.96
4582B	1.68
4583B	0.86
4584B	0.44
4585B	0.38
4597CP	4.40
4598B	4.40
4599B	3.42
4720B	POA
4720V	POA
4723B	POA
4724B	POA
4731VP	7.20
4737VP	17.30
4738VP	17.50
4750VD	30.20
4752VP	31.71
4753VP	POA
4754VP	POA
40085	0.94
40097	0.48
40098	0.48
40100	1.14
40101	0.76
40102	0.92
40103	0.68
40105	0.64
40106	0.30
40107	0.27
40108	POA
40109	0.50
40110	0.80
40114	1.96
40116	9.60
40117	1.66
40147	0.95
40160	0.46
40161	0.46
40162	0.46
40163	0.46
40174	0.34
40175	0.36
40181	POA
40192	0.48
40193	0.52
40194	POA
40195	0.78
40240	1.36
40244	1.36
40245	1.36
40257	1.32
40373	1.10
40374	1.10
45000P	POA
45026	3.40
45027	4.61
45028	3.45
45040	7.44
45041	7.88
45100	1.63
45106	5.40
45109	3.08
45138	1.48
45145	9.25
45146	10.44
45151	15.00
45152	16.50
45156	13.50
45157	11.06
45158	11.94
45159	18.90
45406	2.10
45407	4.98
45411	POA
45414	10.55
45428	POA
45433	POA
45440	12.75
45441	POA
45453	POA

4000 Series Surface Mount

4001BT	0.25
4002BT	0.25
4011BT	0.25
4011UBT	0.25
4012BT	0.25
4013BT	0.36
4015BT	0.67
4016BT	0.34
4017BT	0.62
4018BT	0.62
4020BT	0.76
4021BT	0.52
4023BT	0.25
4024BT	0.61
4025BT	0.25
4027BT	0.36
4028BT	0.45
4029BT	0.79
4040BT	0.65
4042BT	0.59
4046BT	1.13
4047BT	0.85
4049BT	0.85
4050BT	0.38
4051BT	0.67
4052BT	0.79
4053BT	0.86
4060BT	0.67
4066BT	0.47
4068BT	0.25
4069UBT	0.25
4070BT	0.28
4071BT	0.25
4075BT	0.25
4077BT	0.28
4078BT	0.25
4081BT	0.25
4093BT	0.36
4094BT	0.76
4508BT	1.64
4510BT	0.81
4511BT	1.08
4512BT	0.52
4514BT	1.76
4516BT	0.81
4518BT	0.94
4520BT	0.94
4521BT	0.86
4522BT	0.90
4528BT	0.70
4534BD	3.42
4538BT	0.84
4541BT	0.84
4543BT	0.82
4555BT	0.70
4556BT	0.84
4585BT	0.76
40106BT	0.42
40244BT	1.08
40373BT	1.82

74 SERIES DIL

7400	0.20
7402	0.20
7403	0.20
7404	0.25
7405	0.25
7406	0.30
7406A	0.33
7407	0.30
7407A	0.32
7408	0.23
7410	0.15
7412	0.40
7413	0.27
7414	0.28
7416	0.33
7417	0.30
7420	0.20
7425	0.15
7426	0.20
7427	0.18
7430	0.22
7432	0.27
7437	0.24
7438	0.38
7440	0.48
7442	0.38
7445	0.70
7446	0.84
7447	0.84
7447A	0.90
7451	0.25
7454	0.40
7470	0.27
7472	0.18
7473	0.23
7474	0.35
7475	0.25
7476	0.23
7480	0.79
7483	0.60
7485	0.28
7486	0.26
7490	0.39
7490A	0.72
7491	1.60
7492	0.42
7492A	0.70
7493	0.54
7493A	0.61
7495A	0.69
74104	0.42
74107	0.30
74110	4.16
74116	3.10
74118	3.95
74119	1.98
74121	0.48
74123	0.32
74125	0.37
74126	0.54
74128	0.80
74132	0.51
74150	1.36
74151	0.42
74151A	0.62
74154	1.56
74155	0.78
74157	0.43
74158	0.98
74159	3.20
74160	0.47
74161A	1.60
74163	0.80
74164	0.56
74165	0.98
74166	0.66
74174	0.68
74175	0.53
74184	2.95
74185	1.10
74192	0.72
74193	1.03
74221	1.42
74259	2.45
74265	0.80
74273	2.40
74276	2.40
74279	0.73
74283	0.68
74298	2.60
74365	0.44
74367	0.66
74393	2.05
74403	POA
74423	POA

74LS SERIES

74LS00	0.12
74LS01	0.12
74LS02	0.12
74LS03	0.12
74LS04	0.12
74LS05	0.12
74LS06	0.39
74LS07	0.39
74LS08	0.12
74LS09	0.12
74LS10	0.12
74LS11	0.12
74LS12	0.12
74LS13	0.16
74LS14	0.18
74LS15	0.12
74LS20	0.14
74LS21	0.14
74LS22	0.14
74LS24	0.33
74LS26	0.14
74LS27	0.14
74LS28	0.14
74LS30	0.14
74LS31	1.96
74LS32	0.13
74LS33	0.13
74LS37	0.14
74LS38	0.13
74LS40	0.13
74LS42	0.23
74LS44	1.62
74LS47	0.42
74LS48	0.46
74LS49	0.62
74LS51	0.12
74LS54	0.12
74LS55	0.30
74LS73	0.17
74LS73A	0.24
74LS74	0.16
74LS74A	0.18
74LS75	0.20
74LS76	0.22
74LS76A	0.24
74LS77	0.42
74LS78	0.22
74LS83	0.30
74LS83A	0.34
74LS85	0.34
74LS86	0.20
74LS90	0.24
74LS91	0.50
74LS92	0.32
74LS93	0.24
74LS95	0.38
74LS96	0.46
74LS107	0.23
74LS107A	0.28
74LS109	0.20
74LS109A	0.26
74LS112	0.20
74LS112A	0.26
74LS113	0.20
74LS113A	0.26
74LS114	0.22
74LS114A	0.26
74LS122	0.30
74LS123	0.30
74LS125	0.21
74LS125A	0.28
74LS126	0.28
74LS126A	0.28
74LS132	0.20
74LS133	0.18
74LS136	0.22
74LS137	0.62
74LS138	0.24
74LS139	0.26
74LS145	0.54
74LS147	0.86
74LS148	0.70
74LS151	0.24
74LS153	0.24
74LS154	0.70
74LS155	0.24
74LS156	0.24
74LS157	0.22
74LS158	0.24
74LS160	0.32
74LS160A	0.36
74LS161	0.32
74LS161A	0.36
74LS162	0.32
74LS162A	0.36
74LS163	0.32
74LS163A	0.36
74LS164	0.28
74LS165	0.48
74LS166	0.52
74LS168	0.58
74LS169	0.52
74LS170	0.66
74LS173	0.30
74LS173A	0.42
74LS174	0.28
74LS175	0.24
74LS181	1.40
74LS182	1.58
74LS183	1.58
74LS189A	1.88
74LS190	0.30
74LS191	0.38
74LS192	0.38
74LS193	0.38
74LS194	0.38
74LS194A	0.44
74LS195A	0.42
74LS196	0.42
74LS197	0.40
74LS221	0.38
74LS224	24.50
74LS240	0.32
74LS241	0.32
74LS242	0.32
74LS243	0.32
74LS244	0.32
74LS245	0.32
74LS247	0.34
74LS248	0.38
74LS249	0.68
74LS251	0.22
74LS253	0.34
74LS256	0.50
74LS257	0.24
74LS257A	0.34
74LS258	0.24
74LS258A	0.32
74LS259	0.48
74LS260	0.20
74LS266	0.20
74LS273	0.32
74LS275	6.10
74LS279	0.25
74LS280	0.86
74LS283	0.44
74LS290	0.24
74LS292	18.35
74LS293	0.24
74LS294	18.35
74LS295	0.58
74LS295A	0.64
74LS298	0.63
74LS299	1.18
74LS321	5.62
74LS322	1.58
74LS322A	1.64
74LS323	1.64
74LS347	1.40
74LS348	1.18
74LS352	0.84
74LS353	0.88
74LS363	1.38
74LS364	1.38
74LS365	0.21
74LS365A	0.26
74LS366	0.28
74LS366A	0.32
74LS367	0.21
74LS367A	0.30
74LS368	0.28
74LS368A	1.32
74LS373	0.32
74LS374	0.32
74LS375	0.32
74LS377	0.36
74LS378	0.62
74LS379	0.86
74LS381A	3.05
74LS385	2.22
74LS386	0.46
74LS390	0.30
74LS393	0.34
74LS395	0.36
74LS395A	0.66
74LS396	1.68
74LS398	1.22
74LS399	0.62
74LS423	1.82
74LS445	1.88
74LS450	5.60
74LS461	4.45
74LS461A	5.40
74LS465	3.82
74LS467	3.82
74LS468	3.82
74LS469	5.62
74LS469A	6.70
74LS490	0.90
74LS491A	5.98
74LS502	2.60
74LS540	0.93
74LS541	0.76
74LS546	4.43
74LS548	4.18
74LS549	4.18
74LS568	1.62
74LS569	1.14
74LS573	1.34
74LS574	1.34
74LS590	4.53
74LS591	6.58
74LS592	5.28
74LS593	6.25
74LS595	3.76
74LS597	4.64
74LS604	4.46
74LS605	4.46
74LS606	4.46
74LS610	9.95
74LS611	11.94
74LS612	6.68
74LS620	1.38
74LS621	1.76
74LS622	1.66
74LS623	1.28
74LS624	2.10
74LS625	2.28
74LS626	2.18
74LS627	2.33
74LS628	2.18
74LS629	0.93
74LS631	42.20
74LS640	0.84
74LS641	0.86
74LS641-1	1.28
74LS642	0.82
74LS642-1	2.48
74LS643	0.84
74LS643-1	2.48
74LS644	0.84
74LS644-1	2.48
74LS645	0.86
74LS645-1	1.28
74LS646	7.62
74LS647	6.68
74LS648	6.68
74LS649	6.68
74LS651	6.30
74LS652	6.94
74LS653	5.58
74LS654	5.58
74LS668	0.83
74LS669	0.56
74LS670	0.68
74LS673	28.46
74LS674	17.60
74LS682	2.62
74LS683	2.85
74LS684	3.85
74LS685	2.82
74LS686	3.64
74LS687	2.42
74LS688	1.68
74LS689	2.45
74LS693	4.90
74LS697	15.84
74LS716	6.58
74LS718	6.58
74LS724	1.24
74LS748	1.15
74LS794	8.86
74LS795	2.34
74LS796	2.34
74LS797	2.34
74LS848	3.20

74HC SERIES

74HC00	0.13
74HC02	0.13
74HC03	0.13
74HC04	0.15
74HCU04	0.19
74HC05	0.14
74HC08	0.17
74HC10	0.19
74HC11	0.13
74HC14	0.24
74HC14A	0.28
74HC20	0.18
74HC21	0.19
74HC27	0.19
74HC30	0.19
74HC32	0.19
74HC42	0.29
74HC51	0.19
74HC58	0.28
74HC73	0.23
74HC74	0.23
74HC75	0.27
74HC76	0.27
74HC77	0.34
74HC85	0.32
74HC86	0.24
74HC107	0.26
74HC109	0.24
74HC112	0.27
74HC113	0.27
74HC123	0.34
74HC125	0.31
74HC126	0.32
74HC131	0.35
74HC132	0.27
74HC133	0.31
74HC137	0.44
74HC138	0.32
74HC139	0.21
74HC141	0.41
74HC147	0.41
74HC148	0.37
74HC151	0.31
74HC153	0.31
74HC154	0.89
74HC155	0.47
74HC157	0.33
74HC158	0.32
74HC160	0.43
74HC161	0.38
74HC162	0.43
74HC163	0.43
74HC164	0.38
74HC165	0.55
74HC166	0.59
74HC173	0.51
74HC174	0.32
74HC175	0.32
74HC181	1.30
74HC182	0.40
74HC190	0.45
74HC191	0.48
74HC192	0.52
74HC193	0.40
74HC194	0.45
74HC195	0.32
74HC221	0.41
74HC237	0.49
74HC238	0.50
74HC240	0.44
74HC241	0.44
74HC242	0.54
74HC243	0.59
74HC244	0.43
74HC245	0.44
74HC251	0.24
74HC253	0.35
74HC257	0.32
74HC258	0.49
74HC259	0.44
74HC266	0.32
74HC273	0.41
74HC279	0.34
74HC280	0.60
74HC283	0.38
74HC298	0.49
74HC299	1.04
74HC323	1.07
74HC354	0.37
74HC356	0.44
74HC365	0.33
74HC366	0.35
74HC367	0.32
74HC368	0.35
74HC373	0.41
74HC374	0.38
74HC375	0.51
74HC377	0.51
74HC386	0.19
74HC390	0.36
74HC393	0.41
74HC423	0.64
74HC521	0.64
74HC533	0.64
74HC534	0.60
74HC540	0.69
74HC541	0.58
74HC563	0.59
74HC564	0.59
74HC573	0.64
74HC573A	0.68
74HC574	0.64
74HC589	1.10
74HC590	0.80
74HC592	0.80
74HC593	1.12
74HC595	0.84
74HC597	0.79
74HC620	1.09
74HC623	1.09
74HC633	1.09
74HC640	0.89
74HC643	0.89
74HC645	0.94
74HC646	1.19
74HC648	1.19
74HC651	0.99
74HC652	0.99
74HC658	3.02
74HC659	3.02
74HC664	3.02
74HC665	3.02
74HC670	0.74
74HC677	2.55
74HC678	3.98
74HC680	2.58
74HC682	2.84
74HC684	3.84
74HC688	0.79
74HC690	1.09
74HC691	1.09
74HC692	1.16
74HC693	1.16
74HC696	POA
74HC697	1.06
74HC698	1.06
74HC699	1.06
74HC4002	0.24
74HC4015	0.72
74HC4016	0.43
74HC4017	0.30
74HC4020	0.49
74HC4022	0.38
74HC4024	0.33
74HC4028	0.39
74HC4040	0.33
74HC4046	1.30
74HC4049	0.37
74HC4050	0.36
74HC4051	0.64
74HC4052	0.74
74HC4053	0.68
74HC4053A	0.74
74HC4060	0.32
74HC4061	1.70
74HC4066	0.31
74HC4066A	0.36
74HC4072	0.30
74HC4075	0.25
74HC4078	0.31
74HC4094	0.49
74HC4316	0.68
74HC4351	0.89
74HC4511	0.55
74HC4514	1.19
74HC4515	1.19
74HC4518	0.54
74HC4520	0.59
74HC4538	0.74
74HC4543	0.55
74HC7001	0.68
74HC7002	0.68
74HC7032	0.68
74HC7266	0.56
74HC7074	1.34
74HC7292	0.77
74HC7294	0.77
74HC40102	0.84
74HC40103	0.84
74HC40105	1.40

74HCT SERIES

74HCT00	0.22
74HCT02	0.22
74HCT03	0.22
74HCT04	0.22
74HCT08	0.22
74HCT10	0.22
74HCT11	0.22
74HCT14	0.26
74HCT20	0.26
74HCT21	0.26
74HCT27	0.22
74HCT30	0.22
74HCT32	0.22
74HCT42	0.46
74HCT73	0.36
74HCT74	0.26
74HCT75	0.36
74HCT85	0.60
74HCT86	0.36
74HCT93	0.58
74HCT107	0.40
74HCT109	0.42
74HCT112	0.42
74HCT123	0.64
74HCT125	0.56
74HCT126	0.56
74HCT132	0.50
74HCT137	0.52
74HCT138	0.32
74HCT139	0.45
74HCT147	0.54
74HCT151	0.52
74HCT153	0.44
74HCT154	1.18
74HCT157	0.44
74HCT158	0.44
74HCT160	0.56
74HCT161	0.56
74HCT162	0.56
74HCT163	0.56
74HCT164	0.52
74HCT165	0.52
74HCT166	0.52
74HCT173	0.52
74HCT174	0.52
74HCT175	0.52
74HCT181	2.48
74HCT182	0.96
74HCT190	0.64
74HCT191	0.64
74HCT192	0.64
74HCT193	0.64
74HCT194	0.76
74HCT195	0.78
74HCT221	0.98
74HCT237	0.94
74HCT238	0.51
74HCT240	0.44
74HCT241	0.44
74HCT242	0.76
74HCT243	0.64
74HCT244	0.44
74HCT245	0.44
74HCT251	0.58
74HCT253	0.34
74HCT257	0.48
74HCT258	0.48
74HCT259	0.78
74HCT273	0.68
74HCT280	0.98
74HCT283	0.96
74HCT299	1.64
74HCT354	0.86
74HCT356	0.86
74HCT365	0.54
74HCT366	0.54
74HCT367	0.54
74HCT368	0.54
74HCT373	0.44
74HCT374	0.44
74HCT377	0.64
74HCT390	0.68
74HCT393	0.68
74HCT394	0.98
74HCT521A	1.10
74HCT533	0.68
74HCT534	0.64
74HCT540	0.64
74HCT541	0.64
74HCT563	0.66
74HCT564	0.66
74HCT573	0.64
74HCT574	0.64
74HCT583	1.26
74HCT640	0.90
74HCT643	0.90
74HCT645	0.75
74HCT646	1.28
74HCT648	1.28
74HCT651	1.10
74HCT652	POA
74HCT670	1.10
74HCT673	1.10
74HCT688	1.10
74HCT4002	0.26
74HCT4015	0.76
74HCT4016	0.52
74HCT4017	0.68
74HCT4020	0.74
74HCT4024	0.68
74HCT4040	0.70
74HCT4046	2.10
74HCT4051	0.84
74HCT4052	0.84
74HCT4053	0.84
74HCT4060	0.84
74HCT4066	0.66
74HCT4067	3.32
74HCT4075	0.36
74HCT4094	0.84
74HCT4316	0.68
74HCT4351	1.04
74HCT4510	1.04
74HCT4511	0.94
74HCT4514	1.64
74HCT4515	1.68
74HCT4516	1.08
74HCT4520	0.90
74HCT4538	1.02
74HCT7007	0.26
74HCT7046	2.80
74HCT40102	1.64
74HCT40103	1.48
74HCT40104	1.82
74HCT40105	1.40

74HC SERIES SURFACE MOUNT

74HC00M	0.21
74HC02M	0.21
74HC03M	0.21
74HC04M	0.21
74HCU04	0.21
74HC08M	0.21
74HC10M	0.21
74HC14M	0.34
74HC20M	0.21
74HC30M	0.21
74HC32M	0.21
74HC74A	0.27
74HC75M	0.29
74HC85WM	0.65
74HC86M	0.34
74HC123AM	0.42
74HC125M	0.46
74HC132M	0.42
74HC138M	0.34
74HC139M	0.34
74HC154WM	0.48
74HC157M	0.34
74HC161M	0.42
74HC164M	0.46
74HC165M	0.57
74HC173M	0.44
74HC174M	0.38
74HC221AM	0.65
74HC240WM	0.55
74HC244WM	0.55
74HC245AW	0.61
74HC251M	0.34
74HC259M	0.69
74HC273WM	0.55
74HC367WM	0.53
74HC373WM	0.55
74HC374WM	0.55
74HC390M	0.57
74HC393M	0.53
74HC540WM	0.76
74HC541WM	0.76
74HC573WM	1.09
74HC574WM	0.84
74HC688WM	0.84
74HC4017M	0.44
74HC4020M	0.44

74F SERIES

74F00	0.28
74F02	0.28
74F04	0.28
74F06	0.74
74F07	0.74
74F08	0.28
74F10	0.28
74F11	0.28
74F13	0.62
74F14	0.41
74F20	0.28
74F27	0.28
74F30	0.28
74F32	0.28
74F37	0.41
74F38	0.44
74F40	0.66
74F51	0.44
74F64	0.32
74F74	0.30
74F85	2.36
74F86	0.41
74F109	0.42
74F112	0.72
74F113	1.12
74F114	1.12
74F125	0.60
74F126	0.88
74F132	0.52
74F138	0.58
74F139	0.52
74F148	0.90
74F151	0.52
74F153	0.62
74F157	0.54
74F158	0.54
74F160	1.28
74F160A	1.29
74F161	1.28
74F162	1.28
74F163	1.28
74F164	1.28
74F166	4.32
74F168	3.40
74F169	3.40
74F174	0.76
74F175	0.76
74F181	3.36
74F182	1.22
74F189	4.36
74F190	2.92
74F191	2.92
74F192	2.92
74F193	2.92
74F194	1.31
74F195	2.90
74F219	4.38
74F224	1.92
74F240	0.62
74F241	0.62
74F244	0.62
74F245	0.72
74F251	0.62
74F251A	0.66
74F253	0.62
74F257	0.62
74F257A	0.66
74F258	0.62
74F259	3.72
74F260	0.80
74F269	8.28
74F273	2.20
74F280	0.62
74F283	0.78
74F299	3.36
74F323	4.48
74F350	1.50
74F352	0.64
74F353	1.14
74F365	1.28
74F366	1.30
74F367	1.38
74F368	1.30
74F373	0.62
74F374	0.62
74F378	1.56
74F381	3.68
74F385	11.18
74F395	3.28
74F399	0.98
74F412	5.02
74F413	19.66
74F432	4.48
74F521	1.20
74F524	7.26
74F533	1.20
74F534	1.20
74F537	1.60
74F538	1.60
74F539	1.60
74F540	1.78
74F541	1.76
74F543	4.92
74F544	4.92
74F545	3.36
74F547	6.04
74F563	2.24
74F564	2.24
74F573	1.60
74F574	1.60
74F579	6.64
74F604	5.08
74F620	3.98
74F621	3.52
74F623	3.98
74F646	5.35
74F646	5.15
74F676	10.60
74F821	3.98
74F823	3.98
74F825	3.98
74F827	3.98
74F828	4.48
74F841	4.48
74F843	4.30
74F845	4.30
74F1242	2.41
74F1243	2.41
74F1244	2.12

74AC SERIES

74AC00	0.38
74AC02	0.49
74AC04	0.49
74AC08	0.49
74AC10	0.49
74AC11	0.49
74AC14	0.49
74AC20	0.49
74AC32	0.49
74AC74	0.49
74AC109	0.61
74AC138	0.68
74AC139	0.65
74AC151	0.68
74AC153	0.65
74AC157	0.65
74AC158	0.65
74AC163	0.72
74AC169	1.71
74AC174	0.65
74AC175	0.80
74AC191	1.12
74AC240	0.86
74AC241	0.88
74AC244	0.88
74AC245	1.10
74AC251	0.60
74AC253	0.60
74AC258	0.60
74AC273	1.10
74AC299	2.06
74AC373	0.88
74AC374	0.88
74AC377	0.84
74AC540	0.98
74AC541	0.98
74AC573	1.26
74AC646	3.86
74AC648	3.86

74C SERIES

74C00	0.56
74C02	0.56
74C08	0.56
74C10	0.56
74C14	0.56
74C20	0.98
74C30	0.98
74C32	0.68
74C42	0.98
74C48	1.98
74C73	1.15
74C74	0.68
74C76	1.15
74C85	1.52
74C90	1.25
74C93	2.10
74C95	1.60
74C150	6.10
74C151	4.16
74C154	2.98
74C157	2.48
74C164	1.52
74C165	1.23
74C221	1.54
74C240	2.08
74C244	2.08
74C373	2.08
74C374	2.08
74C901	0.86
74C902	0.86
74C903	1.52
74C906	0.86
74C907	1.52
74C908	2.80
74C911	14.42
74C912	8.30
74C914	1.16
74C915	2.74
74C922	4.35
74C923	4.35
74C925	9.30
74C926	9.30
74C929	9.30

74S SERIES

74S00	0.44
74S02	0.44
74S03	0.51
74S04	0.42
74S08	0.42
74S09	0.48
74S10	0.98
74S11	0.48
74S20	0.48
74S32	0.78
74S40	0.25
74S51	0.36
74S64	0.36
74S74	0.98
74S86	1.12
74S112	1.08
74S124	2.42
74S132	0.98
74S133	0.73
74S134	1.95
74S138	0.88
74S139	0.88
74S140	0.78
74S153	1.26
74S157	1.72
74S163	2.60
74S174	0.92
74S175	1.35
74S182	3.29
74S189	2.14
74S195	2.40
74S240	1.00
74S241	1.12
74S244	1.77
74S257	1.22
74S258	1.22
74S260	0.70
74S273	2.44
74S274	2.42
74S280	0.96
74S283	1.90
74S374	2.18
74S394	2.10
74S412	2.10
74S436	2.62
74S437	2.62
74S472	2.32
74S734	2.62

VOLTAGE REGULATORS

78008AP	1.15
7805	0.28
7805A	0.32
7805FA	0.45
7806	0.28
7808	0.28
7809	0.32
7812	0.28
7812A	0.32
7812CTC	0.32
7815	0.28
7818	0.28
7824	0.28
78L05	0.24
78L05A	0.28
78L05ACLP	0.40
78L05ACZ	0.28
78L12	0.28
78L12A	0.28
78L12ACZ	0.30
78L15	0.28
78L24	0.28
78L56	1.10
78M05	0.32
78M05A	0.36
78M12	0.32
78M12A	0.36
78M13A	0.65
78M15	0.32
78S05	0.48
78S12	0.48
78S15	0.55
7905	0.28
7905A	0.32
7905FA	0.60
7909	0.55
7912	0.30
7912A	0.36
7912FA	0.78
7915	0.30
7918	0.30
7924	0.30
79L12A	0.35
79L12ACP	0.35
79M05	0.42
79M05A	0.42
79M05FA	0.65
79M12	0.50
79M12A	0.60
LM317T	0.50
LM317MP	1.06
LM317LZ	0.55
LM338K	4.45
UA78GU1C	1.02
UA79GU1C	1.02
RC4195N	1.80

DIODES

1N2986RB	18.20
1N3881	2.54
1N3997A	6.55
1N4001	0.04
1N4002	0.04
1N4003	0.04
1N4006	0.04
1N4007	0.04
1N4148	0.03
1N4149	0.06
1N4150	0.08
1N4446	0.06
1N4728A	0.24
1N4735A	0.24
1N4736A	0.24
1N4740A	0.24
1N4743A	0.24
1N4744A	0.24
1N4756A	0.24
1N5226B	0.09
1N5232B	0.09
1N5234B	0.09
1N5337B	0.48
1N5349B	0.48
1N5352B	0.48
1N5357B	0.48
1N5365B	0.48
1N5366B	0.48
1N5370B	0.48
1N5380B	0.48
1N5401	0.11
1N5402	0.11
1N6287A	1.55
1N825	1.80
1N825A	1.34
1N827	1.40
1SS252	0.20
5082-2800	0.66
5082-2810	1.40
5082-2835	0.44
AA119	0.60
AA144	0.72
AAZ15	0.58
AAZ17	0.58
AAZ18	0.48
BAV10	0.08
BAV45	4.98
BAW62	0.06
BAX16	0.06
BB204	0.32
BB212	2.48
BB405B	0.22
BB809	0.60
BY179	0.42
BY260-200	3.58
BY261-200	3.98
BYV28-100	0.99
BYV32-50	1.60
CV8805	0.60
DS16C	0.40
MV1404	15.90
MV209	1.20
OA200	0.10
OA202	0.20
OA47	0.14
OA90	0.14
P6KE36A	0.88
P6KE47A	0.88
REC53A	0.40
ZPD2.7V	0.06

ZENER DIODES MISC.

BZY93C7V5	2.66
BZY93C15	2.66
BZY93C18R	2.66
BZY93C20	2.66
BZY93C24V	2.66
BZY93C33R	2.66
BZT03C120	0.40
BZX61C9V2	0.09
BZX61C24V	0.09

ZENER DIODES
400mW
2.4V to 75V
Price: 6p each

ZENER DIODES
500mW
2.4V to 200V
Price: 6p each

ZENER DIODES
1.3 WATT
2.7V to 200V
Price:10p each

ZENER DIODES
3.0 WATT
7.5V to 270V
Price:40p each

ZENER DIODES
5.0 WATT
3.3V to 200V
Price:42p each

ZENER DIODES
STUD MOUNT
20 WATT
7.5V to 75V
Price: £4.94 ea.

BRIDGE RECTIFIERS

0.9A/200VDIL	0.38
3.0A/200V SIL	0.57
6A/100V SIL	1.60
8A/200V SIL	1.96
35A/100V Sqr	2.98
KBPC1002	1.64
KBPC3502	2.98
W005- 1A/50V	0.32
W02G- 1.5A	0.40
2W02	0.40
2KBB10R/SIL	0.66
2KBB20R/SIL	0.70
B80C1500/Sq	0.35
B80C1500SIL	0.60
SKB6008/60A	POA

CRYSTALS

HC49(HC18/U)

Freq.MHz	
1.843200	1.60
2.000000	1.66
2.457600	1.49
3.276800	0.98
3.579545	1.10
3.686400	1.02
4.000000	1.02
4.096000	1.10
4.194304	1.10
4.433619	1.10
4.608000	1.10
4.915200	1.20
5.000000/S	1.02
5.068800	1.10
5.242880	1.20
5.888200	1.80
6.000000	1.02
6.144000	1.02
6.400000	1.64
6.552000	1.40
6.553600	1.21
7.372800	0.78
8.000000	1.00
8.867230	1.34
9.830400	1.20
10.00000	1.10
10.69500	1.90
11.00000	1.10
12.00000	0.92
13.87500	2.40
14.00000	1.64
14.31818/S	0.85
14.74560/S	1.10
14.74560	1.10
15.00000/S	1.10
16.00000	1.02
16.00000/S	1.20
18.43200/S	1.10
19.66080/S	1.20
20.00000/S	1.60
22.11840/S	1.68
24.00000/S	1.82
27.64800/S	1.20
30.00000/S	6.99
32.00000/S	1.40
48.00000/S	1.68

S = Series

HC33/U

0.204800	8.23
0.307200	6.99
1.000000	3.95
1.843200	3.71
2.000000	4.65
2.097152	3.71
2.457600	1.92
2.500000	1.92
3.000000	2.25

HC49/U4H

3.276800	1.66
3.579545	1.58
5.068800	2.25
7.864320	1.49
8.000000	1.14
10.00000	2.25
11.05920	2.40
12.00000	1.14
14.00000	2.25
16.00000	1.14
20.00000	1.52
24.00000	1.90

UM-1

8.000000	2.25
8.192000	2.02
10.00000	2.25
11.00000	2.25
12.28800	2.66
15.00000	2.25
17.73447	2.80
18.00000	2.50
20.00000	2.25
21.00000	2.25
24.00000	2.80

CRYSTALS MISC.

HC43/T 1.000000	6.99
MINI CYLINDER 0.032768	0.88
WATCH 0.032768	0.82

CRYSTAL OSC. MODULES

8pin DIL
Plastic pkg
TTL Output
4 Pins spaced at corners of 8pinDIL

Freq.= MHz
4, 4.9152, 8, 10, 12, 16 & 20
Price: £2.98 ea.

24, 32, 40 & 50MHz
Price £3.40 ea.

8pin DIL
Sealed Metal
Package
HCMOS Output

13.2mm sq.
Pins spaced at corners of 8pinDIL
Freq.= MHz
3.6864,4,8,10,12,16, 20,24,32,40 & 50
Price: £4.20 each

TTL Output
14pin DIL Layout
Sealed Metal
4pin Pkg
Freq.= MHz
1MHz **£8.90 ea.**

4,4.9152,6,8,9.8304, 10,12,15,16, 18.432, 19.6608, 20, 24, 25 & 30MHz
Price: £3.52 ea.

30, 32, 32.768, 33.33, 40 & 50MHz
Price: £4.45 ea.

Programmable
Crystal
Oscillators

EXO-3C SERIES
8pin DIL Plastic
Package
Freq.= MHz
12, 14.31818, 16, 16.384,19.6608 & 20MHz
Price: £3.92 ea.

16pin DIL Plastic
Package
Programmable for
57 Diff.Frequency

SPG8640AN
0.005 to 600kHz

SPG8640BN
0.0083 to 1MHz

SPG8640CN
0.064 to 768kHz

SPG8650BN
0.00083 to 100kHz

Price: £ 9.25 ea.

DC to DC Converters

TDK CE-0344	5.60
3W5R 15-15	27.50
IPL S.010	23.40

1 Watt DC/DC
5V Input ±Output
DIL & SIL by
Newport
NMA0505±5V
NMA0509±9V
NMA0512±12V
NMA0515±15V
Price:£7.90ea.

DC/DC Converters
by Computer
Products

PM623	24.60
PM671	26.70
PM672	26.70
PM903	44.00
PM951	46.50

RESISTORS

METAL FILM
0.25W 1%
E24 Series
10R to 1M 3p each
N.B. Min Qty. Order
Min. 5pcs per value

METAL FILM
PRECISION
0.25 WATT 0.1%
E96 Series
100R to 255K
Price: £0.94 each

HIGH PRECISION
NON-INDUCTIVE
WIRE WOUND
0.15 WATT 0.1%

Temp.Coeff.3ppm
10R,50R,100R,250R, 10K,100K
Price: £3.85 each

HIGH PRECISION
NON-INDUCTIVE
WIRE WOUND
0.33 WATT 0.1%

Temp.Coeff.3ppm
1R,5R,10R,20R,50R
Price: £3.60 each

100R,120R, 250R, 500R,1K, 2K, 5K, 10K,20K
Price: £3.10 each

MEMORIES

DYNAMIC RAM

4164-10	1.20
4164-12	1.00
4164-15	1.00
41256-8	1.60
41256-10	1.50
41256-12	1.40
41464-12	4.45
41464-10	4.45
4464-10	2.80
414256A-70	3.90
44C256AZ-10	6.95
44C256-8	5.00
511000-85	8.45
HM48416AP-15	4.60
HM48416AP-20	4.25
HY53C256LS-80	1.60
HY53C464LS-80	3.95
HYB511000-85	8.45
KM44C256AZ10	6.95
M5M4464P-15	4.60
MK4116N-54	2.80
MK4564N-15	1.00
NMC3764N-15	1.60
UPD41464C-12	4.20
UPD41464C-15	4.20
UPD416C-2	3.40
UPD416C-3	3.65
UPD446D-1	2.60

STATIC RAM

2114-3L	3.40
6264LP-10	2.40
6264LP-12	2.40
62256LP-12	4.95
62256LP-10	4.95
CDM6116AE3	5.30
CDM6117AE3	5.85
HM1-6116-5	4.38
HM3-6116-5	3.60
HM6116LP-2	2.60
HM6116LP-3	2.60
HM6117LP-3	5.75
HM62256LP-10	7.93
HM6264ALP-12	3.95
HM6264ASP-20	3.95
HM6267P-35	5.07
HM628128LP-80	18.55
HM66204L-12	15.80
KM62256ALP-10	4.60
LH5164D-10L	2.40
P2114AL-2	3.40
P2114AL-4	3.40
PCD5101P	3.30
UPD43256AGU10L	8.33
UPD43256C-12	5.60
UPD4364C-15	4.70

UVPROMS

27C128-25	2.95
27C64A-15	2.74
27C256-15	3.95
27C256-25	3.95
D27256	5.40
HM27C101G-20	9.80
HN27C1024HG10	16.63
HN27C64FP-20T	3.40
HN27C64G-15	4.20
HN27C64G-20	4.20
HN462532P	4.50
HN4827128G-25	4.55
HN482764G	3.80
HY6264LP-10	2.40
M2716-1F1	3.50
M5L2732K	4.40
M5L2764K	3.30
MBM27C64-20/21V	4.90
MBM27C128-30	4.20
MBM27C256-30	5.10
NMC27C256Q-25	4.95
NMC27C64Q-25	3.66
TMS2516JL-45	4.58
TMS27128JL-25	4.60
TMS2716JL-45	4.60
UPD27256D/21V	5.60
UPD2732A/21V	4.95
UPD27C256D-15	5.80
UPD27C512D-15	6.96
UPD27C64D-25	4.95

EEPROMS

AT28C256-15DC	28.50
AT28C64-25	9.80
AT28C64-15	10.95
KM28C256-20	25.84
KM28C256-15	27.50
KM28C64-25	9.20
X2816AD	5.10
X2816AP-25	5.10
X2864AP-35	12.20

MISC. MEMORIES

6341-1J	4.58
AM2148-45DC	5.44
AM27S281PC	3.98
IDT7130LA-100P	10.43
IDT7132LA-100P	11.19
MB8414E	4.95
MCM4027AC3	2.80
N82S126AN	2.49
N82S153N	5.80
N82S181AN	6.09
NMC6504J-9	3.40
NMC9306N	1.45
P5101L-1	3.90
TBP18S030N	1.74
TBP24S10N	2.90
TBP24SA10N	3.15
TC5501P	3.50
TC5504AP-2	3.40
TC5516PL-15	4.20
TC5517AP-2	4.20
TC5565PL-15	3.60
TMS4014JDL	3.40

CAPACITORS SURFACE MOUNT

Multilayer Ceramic
63 VOLT
Case Size: 1206
L2xW1.25mm

10pF 22pF 33pF 47pF 100pF 220pF 330pF 470pF 1000pF 2200pf 3300pF 4700pF 10000, 22000pF 33000pF
Price: 15p each

47000pF 100000pF
Price: 18p each

MICROPROCESSOR & SUPPORT ICs

100114DEC	7.40
100141DC	9.80
6321P	4.20
63485CP32/sm	19.95
63B03XP	10.07
6502	2.94
6502A	3.90
6520P	4.40
6522	4.40
6522A	5.26
6551	4.43
6551A	4.43
65C02P2	5.84
65C02P3	6.98
65C102P2	7.00
65C22P2	4.80
65C51E-1	3.80
65C51E-2	4.38
68000P-10/12	POA
68000P-16	POA
68000P-8	4.95
68008P-8	POA
68010P-12	POA
6802P	2.95
6803AP	4.98
6805E3E	9.18
6810P	4.35
6821P	1.52
6840P	2.20
6844P	17.20
6845P	4.86
6845SP	5.40
68A00P	7.02
68A09P	7.62
68A21P	3.03
68A40P	2.36
68A50P	2.82
68B09P	3.98
68B21P	1.98
68B40P	2.98
8080A	4.96
8085AH-2	5.98
8086	3.40
8086-2	3.90
80C286-12/pga	48.50
80C286-8/plcc	24.40
80C85A	4.95
80C85A-2	5.94
8118-5CH	7.60
93C46A	4.67
93C46N	4.40
93L34DC	7.08
AM25LS2568P	2.68
AM25LS2569P	2.68
AM2602PC	2.30
AM26LS31DC	2.30
AM26LS31PC	1.26
AM27S191ADC	10.20
AM27S281PC	6.25
AM2964BDC	12.36
AM2965DC	6.36
AM2966PC	3.98
AM29826DC	3.34
AM685DL	9.82
AM8238PC	5.60
AM9050CDC	4.95
AM9050CPC	4.60
AM9102CPC	2.82
AM9114BDM	9.96
AM9551PC	9.66
AM96L02PC	3.35
AY-5-8136	6.45
AY-5-8136-006	6.45
C1164/SMD	4.98
C8231A	59.00
C8253	3.60
CA80C85B	5.98
CD82C85	9.62
CD82C86H-5	9.74
CG80C286-12	48.50
CG80C286-16	65.00
COM8136	6.45
COM81C17	8.15
CP82C54	6.42
CRT-8004-001	9.65
CS8205	8.92
D3232	5.60
D8086	5.48
D8086-2	8.80
D8202A	POA
D8254-2	6.42
D8284A	3.90
D8288	6.48
D82C284-12	9.60
D82C284-8	7.85
D82C288-10	10.96
D82C288-12	11.85
D82C288-8	9.36
D8748H	9.95
DM9601N	2.45
DP8228N	6.36
DP8238N	6.36
DP8304BN	2.34
DP8311N	6.54
DS1221	6.44
DS1231-20	4.44
DS1232	3.26
DS3486N	3.20
DS3487N	3.20
DS34C86N	4.80
DS34C87N	4.80
DS3631N	3.33
DS3632N	2.81
DS3633N	3.33
DS3634N	2.81
DS3691N	4.96
DS3862N	7.38
DS5000-32-12	47.50
DS8640N	1.20
DS8820AN	2.95
DS8832N	2.68
DS8836N	2.44
DS8837N	2.40
DS8838N	2.40
EF6803A-1P	3.80
EF6803P	3.80
EF6821P	1.30
EF68B09P	3.18
EF68B21P	1.44

EP610PC-35	POA
HD1-0165-5	10.96
HD146818AP	4.20
HD3-6402-9	6.16
HD3-6440-9	8.89
HD3-6495-9	8.89
HD44883	9.52
HD46505SP	9.85
HD46802P	5.50
HD6321P	4.20
HD63485PS32	32.50
HD63B03XP	11.95
HD68000-8	11.59
HD6845SP	6.92
HD68A52P	5.60
HD68B21P	4.29
HI3-7159-5	20.98
HI3-7159A-5	23.40
HM10422	14.30
ID82C86H	17.06
IM6402AIPL	7.09
IM6402IPL	3.73
IM6403IPL	POA
IMS2600P-15	4.40
INS8250N	7.80
INS8250N-B	7.80
M5M82C51AP	4.20
M5M82C54P-6	5.40
MAB8031AH12P	4.56
MAB8035HL-6P	5.98
MC10103P	1.98
MC10115L	3.21
MC10115P	1.98
MC146805E2P	9.18
MC68000P12/16	POA
MC68010P10/12	POA
MC6802P	2.47
MC6809P	6.78
MC6821P	1.80
MC6840P	5.05
MC6844P	18.40
MC6845P	7.38
MC6850P	3.35
MC68705R3P	25.35
MC68A00P	7.02
MC68A09P	7.62
MC8314P	6.60
MCM6810P	3.00
MCM68A10P	5.35
MM53200N	3.40
MM58167BN	10.64
MM58174AN	14.80
MM58274CN	9.18
MSM5832RS	3.39
MSM80C35RS	4.90
MSM80C39/SMD	6.45
MSM80C85A	3.95
MSM80C85A-2	5.98
MSM80C86	7.60
MSM81C55	4.60
MSM82C51A	3.58
MSM82C53-2	3.98
MSM82C53-5	3.58
MSM82C54-2	4.20
MSM82C59A-2	3.98
MSM82C84A	3.30
MSM82C84A-2	3.60
MSM82C88	12.60
N80C286-10/pl	24.50
N80C286-12/pl	29.54
N80L286-8C2/pl	36.20
N8235N	3.68
N8264N	3.68
N82S126AN	3.25
N82S181F	10.04
NS16450N	4.68
NS16550AFN	12.60
NSC800N-1	10.80
P8032AH	4.29
P8051AH	11.20
P8052AH/Basic	23.45
P8080A	3.90
P8085A-2	5.98
P8085AH-2	5.98
P8088	4.80
P80C31BH	4.54
P80C86AL-2	12.60
P8155H/2	6.98
P8185	18.10
P8205	2.00
P8212	2.40
P8226	2.40
P8251A	3.90
P8253	2.80
P8255A-5	3.90
P8259	2.85
P8259A	3.20
P8274	9.98
P8279-5	3.20
P8282	2.64
P8286	3.60
P82C54	4.10
P82C54-2	4.80
PAL10L8CN	1.90
PAL12H6CN	1.90
PAL16R4BCN	2.17
PAL20L10CNS	4.35
PAL20X8CNS	3.32
PALC16L8Q-25CQ	6.10
PALC20L8Z-45CQS	5.17
PALC22V10H-35QS	8.34
PCD8584P	8.28
PCF8566P	8.28
PCF8566T	8.28
PCF8570P	7.85
PCF8573P	6.72
PCF8574P	5.90
PCF8574T	5.90
PCF8591P	9.35
R6502AP	5.70
R6520P	4.40
R6522	4.40
R6522AP	5.80
R65C02P2	5.84
R65C02P3	6.90
R65C02P4	8.95
R65C102P2	6.85
R65C21P2	5.94
R65C22P2	4.80

SAB80C32P	5.95
SAB8155-P	3.82
SAB8259AP	3.59
SAB82C54-2-P	4.12
SAB82C55A-2-P	4.80
SC80C451ccn64	13.60
SCN2661bc1n28	3.35
SCN2661ccn28	3.35
PAL16R4-15CN	2.98
TL16C552FN	12.58
TMP7002NL-2	4.97
TMP8085AP-2	5.98
TMS3477NL	6.68
TMS3700NSB	8.78
TMS3702ANS	8.78
TMS3835ANS	7.55
TMS77C01NL	10.74
TMS9900NL	24.40
TMS9901NL	14.16
TMS9902ANL	15.94
TMS9914ANL	23.10
TMS9928ANL	7.40
TMS9995JDL	69.85
UA9636ACP	1.98
UA9637A	1.98
UA9638CP	1.98
UA9639CP	1.98
UM6845B	4.95
UM9151	POA
UM9151-3	POA
UPB8238	POA
UPB8282C	4.98
UPB8284AD	4.98
UPB8286C	4.98
UPD70108C-10	9.10
UPD70108C-8	6.95
UPD70116C-10	12.90
UPD70116C-8	9.20
UPD71055C	4.38
UPD7201AC	11.68
UPD7201C	6.80
UPD765AC	5.42
UPD765AC	5.42
UPD780C-1	4.76
UPD80C39HC	8.42
UPD8155HD	5.84
UPD8251AFC	4.08
UPD8253C-2	3.32
UPD8253C-5	3.32
UPD8286C	POA
UPD8741AD	12.52
UPD8749HC	13.98
V20-10MHz	9.10
V20-8MHz	6.95
V30-10MHz	12.90
V30-8MHz	9.20
V61C30P	7.80
VC0106N6	8.60
Z0800110PSC	16.90
Z0868112PSC	3.20
Z180-MPU	POA
Z8001B-CPU	11.96
Z8018008VSC	8.25
Z80A-CPU	1.25
Z80A-CTC	1.98
Z80A-DART	3.15
Z80A-DMA	3.95
Z80A-PIO	1.25
Z80A-SIO/0	3.40
Z80B-CPU	1.52
Z80B-CTC	3.00
Z80B-DART	5.80
Z80B-DMA	POA
Z80B-PIO	2.20
Z80B-SIO	4.50

TELECOM & SPECIAL FUNCTION ICs

62X0890-U18	3.70
707W02020	5.25
733W00124	5.25
AMA1503GXB	4.68
BAA1505	1.80
CLA25106/PLCC	5.95
GA05001GDB	3.20
KS-49258/PLCC	5.92
MJ1454BB	7.65
MK5175N	3.80
OC-147-7	2.40
PBD352303	4.35
PP34C108	6.80
Q4704	3.60
QMV16BP5	7.98
QMV18C	6.95
QMV18CN1	7.85
QMV18CW1	7.85
QMV25C	8.42
QMV62AW1	6.90
S4534-AMI	4.20
SA336931	2.95
SAA5025D	5.40
SCM66115P	3.40
SGS7P050	4.55
SP1450B	5.76
ULA1RB029E1	6.80
ULA20RK008E1	59.72
XR-T5683	3.60
ZNA2L029J-BS	3.80
ZNPCM1J-BS	8.95

OPTO ELECTRONICS

4N25	0.60
4N26	0.60
4N33	0.40
4N38	0.56
6N139	1.60
CNX36	0.38
CNY17-3	0.64
CNY21N	POA
DF08	0.40
HCPL-2200	5.98
HCPL-2231	5.98
HCPL-2602	5.68
HCPL-2630	3.68
HCPL-2730	3.45
HCPL-2731	3.20
HCPL-4200	5.98
ILD74	1.44
ILQ1	1.60
ILQ74	2.25
ISQ74	2.25
TIL100	1.98
TIL111	0.60
TIL113	0.60
TIL117	0.85
TIL119	1.20
TIL311	9.65
TLP504A	1.58
TLP521-4GB	4.20
TORX173	4.96
TOTX173	4.96

LINEAR & MISCS.

3630BM/BB	3.40
49620/BB	POA
555-TIMER	0.20
6341-1J	POA
741-OPAMP	0.18
AD0P07CN	2.14
AD520JN	POA
AD524	21.52
AD534JH	18.24
AD537JH	POA
AD548JN	1.53
AD578JN	POA
AD581JH	6.96
AD581KCSA/SMD	7.85
AD585AQ	24.60
AD592CN	14.68
AD594AD	10.56
AD595AD	6.65
AD648JN	3.40
AD707JN	2.82
AD711JN	2.34
AD712JN	3.34
AD7245JN	POA
AD741KN	3.69
AD7523KN	6.80
AD7537JN	27.11
AD7537LN	POA
AD7542KN	11.98
AD7543JCWE	POA
AD7578KN	40.15
AD844AN	8.75
ADC0804LCN	4.25
ADC0820CCN	22.40
ADC0834CCN	7.45
ADC804LCWM	12.10
ADC84KG-10	12.66
ADC908HP	16.42
ADDAC80N	19.74
ADG201AKN	4.86
ADOP07CN	1.60
AH0015CD	17.20
AY-3-1270	3.60
AY-5-1013	3.20
AY-5-1013A	5.24
AY-5-1250	POA
AY-5-3600-PRO	9.96
BA6109	1.68
BA6208	1.40
CA3046	0.51
CA3046(SMD)	0.89
CA3054	0.94
CA3059	1.20
CA3078AT	2.42
CA3079	0.88
CA3080E	0.70
CA3081	0.96
CA3089E	1.22
CA3094AE	2.16
CA3096AE	3.48
CA3096CE	2.67
CA3097E	2.60
CA3120E	POA
CA3130BT	19.20
CA3130E	1.10
CA3140AE	1.34
CA3140E	0.60
CA3146E	0.90
CA3160E	1.25
CA3240E	1.94
CA3240E1	2.16
CA324E	0.60
CA3260E	1.68
CA3280AE	5.94
CA3280E	3.42
CA555CE	0.20
CA741CE	0.18
CS5503-KD	POA
CX7925B	POA
D169CJ	POA
DAC0800LCN	4.10
DAC0832LCN	10.67
DAC08CP	2.60
DAC08EP	3.64
DAC1008LCN	10.73
DAC1222LCN	20.40
DG201ABK	3.83
DG211	1.56
DG508ACJ	5.95
DG508CJ	3.25
DS1488N	0.30
DS14C88M/SMD	1.65
DS14C88N	1.65
DS14C89AN	1.65
HA12017	1.44
HA13426	11.96
HA17723	1.10
HD75189P	POA
HEF4754V	22.20
HI1-0201-5	3.60
HI1-508A-5	11.21
HI1-549-5	POA
HI1-574AKD-5	42.50
HI3-0201-5	3.20
HI3-0509A-5	7.15
HI3-201-5	3.20
HIIL1	POA
HS574-AK	18.20
ICL7104-16CPL	26.08
ICL7107CQH/PLCC	5.20
ICL7109CPL	9.85
ICL7116CPL	5.25
ICL7117CPL	5.25
ICL7126CPL	5.35
ICL7135CPI	8.32
ICL7136CPL	6.55
ICL7137CPL	6.98
ICL7606CJN	12.24
ICL7611DCPA	1.32

ICL7621DCPA	1.98
ICL7622	POA
ICL7650CPD	4.48
ICL7650SCPD	5.64
ICL7652BCPD	8.24
ICL7652CPD	8.24
ICL7660CPA	1.40
ICL7660SCPA	3.80
ICL7662CPA	3.80
ICL7663BCJA	6.78
ICL7663BCPA	5.10
ICL7664CPA	7.95
ICL7665ACPA	4.98
ICL7673CPA	1.26
ICL8052ACPD	8.73
ICL8068AJD	9.65
ICL8069CCSQ	3.75
ICL8069DCSQ	2.68
ICL8069DCZR	2.85
ICL8211CPA	2.28
ICL8212CPA	1.10
ICM7170IPG	7.66
ICM7207AIPD	6.80
ICM7207IPD	6.80
ICM7209IPA	3.75
ICM7211AMIPL	4.02
ICM7211MIPL	4.02
ICM7212AMIPL	3.20
ICM7213IPD	4.58
ICM7216AIJI	18.05
ICM7217AIPI	7.20
ICM7217BIJI	10.42
ICM7217IJI	10.42
ICM7218AIJI	6.85
ICM7218AIPI	6.85
ICM7218DIJI	6.85
ICM7218EIJL	14.76
ICM7224IPL	7.77
ICM7226AIJL	26.12
ICM7226BIPL	25.04
ICM7249IDM	POA
ICM7555IBA	2.40
ICM7555IPA	0.64
ICM7556IPD	1.30
IM6403IPL	10.80
L272	2.10
L272M	2.10
L293E	3.90
L297A	4.69
L4805CV	2.20
L487	3.15
L4960	3.15
L702B	2.94
LA6250	POA
LA6358	POA
LA6510	POA
LA6520	POA
LC7132	2.30
LC7522	POA
LC7555	POA
LD111ACJ	POA
LF13508D	18.20
LF311H	10.80
LF347N	1.10
LF351N	0.60
LF353N	0.42
LF355N	0.70
LF356N	1.40
LF357BN	4.98
LF357M/SMD	4.98
LF357N	1.05
LF398N	2.75
LF411CN	0.75
LF412CN	1.21
LF441CN	0.75
LF442CN	0.99
LF444CN	2.40
LH0002CN	10.80
LH0032CG	33.60
LM101AH	5.65
LM10CN	9.24
LM111H	6.74
LM13600N	3.40
LM13700N	2.32
LM1391N	3.40
LM139J	6.60
LM1458N	0.45
LM1496N	2.95
LM1801N	7.92
LM1881N	3.60
LM1889N	7.40
LM1894N	4.16
LM218H	15.75
LM239N	3.90
LM2901N	1.16
LM2903N	0.85
LM2904N	0.85
LM2917N-14	6.10
LM2917N-8	5.80
LM294OCT15	2.73
LM294OCT5	2.10
LM2984CT	7.50
LM301AN	0.36
LM307N	0.84
LM308N	1.10
LM310N	2.98
LM311N	0.30
LM311N-14	2.15
LM312H	8.95
LM317AT	2.60
LM317T	0.52
LM317T-SGS	0.52
LM318N	2.60
LM319N	1.60
LM320LZ-12	0.34
LM324AN	3.66
LM324J	1.20
LM324N	0.35
LM325N	9.40
LM3301N	2.60
LM334Z	1.80
LM335Z	2.16
LM336Z-2.5	1.28
LM336Z-5.0	1.20
LM337T	1.15
LM339AN	1.10
LM339N	0.24
LM340AT12	1.68
LM340T-5	0.30
LM340T12	0.30
LM340T15	0.30
LM340T5	0.30

LM343H	8.80
LM346N	3.96
LM348DP	0.40
LM348N	0.40
LM350T	6.85
LM351N	2.60
LM358N	0.32
LM359N	4.68
LM360H	7.72
LM361M/SMD	6.40
LM363H-100	16.50
LM369DN	3.82
LM369DRC	3.70
LM380N	1.20
LM381AN	7.88
LM385Z-1.2	2.20
LM385Z-2.5	2.20
LM386M-1/SMD	1.65
LM386N-1	1.40
LM386N-3	1.80
LM386N-4	2.60
LM387AN	5.90
LM388N-1	4.25
LM389N	3.40
LM3900N	1.60
LM3909N	2.64
LM3914N	4.40
LM393N	0.30
LM393P	0.30
LM394CN	5.98
LM3999Z	2.76
LM399H	7.85
LM4250J	11.82
LM555CN	0.28
LM565CN	7.48
LM710CH	2.80
LM723CH	2.80
LM723CN	0.70
LM733CN	2.65
LM741CJ-14	2.20
LM741CN	0.45
LM747CH	2.40
LM747CN	0.90
LM78GCP	2.40
LM79GCP	2.40
LM833N	2.82
LS285AB	2.40
LS288B	3.60
LS7210	4.40
LT1006CNB	2.72
LT1010CT	4.58
LT1028CN8	7.32
LT1032CN	4.70
LT1070CT	9.14
LT1083CP	8.82
LT1086CT	2.90
LTC1052	7.97
LTC485CN8	2.16
LTC490	4.40
M5218AL	POA
M5220	POA
M5238L	POA
M5298P	POA
M706B1	1.25
MAX1232CNG	POA
MAX1232CPA	3.57
MAX1259CPE	POA
MAX162ACNG	POA
MAX232ACPE	4.84
MAX232CPE	2.80
MAX232EWE	3.80
MAX232N	2.80
MAX280CPA	6.94
MAX452CPA	5.38
MAX627CPA	2.98
MAX660CPA	5.72
MAX690ACPA	6.58
MAX694CPA	POA
MAX697CPE	POA
MAX7219CNG	7.15
MAX8211CPA	2.28
MAX901BCPE	POA
MC1377P	4.93
MC1413P	0.74
MC14411P	11.38
MC14416L	17.60
MC14495P	4.82
MC145406P	2.10
MC1455P	0.40
MC1455P1	0.60
MC1458P	0.32
MC1488L	2.40
MC1488P	0.58
MC1489A	0.80
MC1489AL	2.25
MC1489AN	0.80
MC1489L	2.20
MC1489P	0.46
MC1496N	2.20
MC1558L	3.32
MC1648P	12.40
MC1658P	12.78
MC1709CPI	1.20
MC1723CP	1.20
MC1741CP	0.45
MC3242AP	7.54
MC3301P	0.88
MC3302P	0.60
MC3340P	1.60
MC3357P	3.20
MC3403P	1.40
MC3446AP	6.75
MC3479P	7.92
MC3523U	5.80
MC4024P	12.78
MCT2	0.84
MCT61	1.18
MF10CCN	8.95
ML924	4.90
MM5309N	5.76
MM53105N	4.98
MM80C95N	1.44
MP7570JD	POA
MUX24EQ	9.60
MUX24FP	9.60
MV500DP	3.05
MV601DP	3.36
MV8870DP	5.52
NE5020N	10.84
NE527N	3.71
NE532N	0.60
NE536H	4.90

NE5530N	3.82
NE5532AN	1.58
NE5532N	0.80
NE5534AN	1.80
NE555N	0.20
NE556/SMD	0.70
NE556N	0.38
NE558N	2.28
NE564N	3.42
NE565N	2.94
NE567N	0.65
NE568N	3.85
NE570N	4.60
NE571N	3.40
NE589N	4.25
NE592/SMD	1.80
NE592N	1.40
NE592N14	0.92
NE602AN	2.98
NE602N	2.25
NE604AN	7.20
NE612AN	2.87
NJM4556D	1.20
NJM4556S	1.20
NJM4558DX	1.20
NJM4558S	1.20
OP07CJ	3.60
OP07CN	0.95
OP07CP	0.95
OP07EP	3.10
OP11GP	5.85
OP177FP	3.71
OP27GP	2.89
OP42FZ	7.44
OP77GP	2.07
OPO7CN	0.95
PM7548HP	14.04
RC4136N	0.90
RC4193N	POA
RC4194N	2.85
RC4207GN	1.92
RC4558	0.90
RC4558P	0.60
REF01CP	2.10
REF01HP	2.98
REF02CP	2.30
REF03GP	2.30
REF25Z	1.12
S2560A	POA
SAA1027	6.51
SAA1043P	7.98
SAA3049P	9.92
SAA5025D	7.65
SAA6002A	10.80
SAS560S	3.40
SED2000FVA	9.60
SFC2301ADC	6.78
SFC2741DC	0.18
SG3524N	4.60
SI7660CJ	1.92
SL1452	6.75
SL2364C	3.97
SL3117B	POA
SL486DP	2.98
SL490B	2.51
SL560CDP	3.00
SL627OC	3.30
SL6700CDP	5.47
SN5281CN	POA
SN55451BJG	POA
SOC12	0.20
SP1648DG	5.53
SP4534	POA
SP4740DP	4.46
SP8629DP	3.44
SP8660DP	4.96
TA7215P	7.20
TA7256P	2.60
TA7368P	POA
TA7658P	POA
TA78005AP	POA
TA8200AH	POA
TA8410K	2.80
TA8449P	POA
TA8659AN	POA
TAA861A	POA
TBA120S	0.60
TBA240B	POA
TBA570	POA
TBA820MT	POA
TBA920	POA
TBA990	POA
TC9106BP	POA
TCA335A	POA
TCA965	POA
TCM1520AP	1.98
TCM1531P	POA
TCM1705AN	POA
TCM3105N	8.97
TCM5087N	2.40
TCM5089N	2.40
TDA1083	2.60
TDA1085A	2.96
TDA1085C	3.80
TDA1151	1.10
TDA1170S	2.80
TDA1515A	4.98
TDA1521A	4.37
TDA1576	2.95
TDA1578A	3.60
TDA2595	3.32
TDA3048N	1.85
TDA3505	POA
TDA3810	POA
TDA440	POA
TDA4510	3.38
TDA4563	3.38
TDA4660	POA
TDA7010T	POA
TDA7052	2.52
TDA8702	6.22
TEA1045	POA
TEA1060	4.20
TEA5620	POA
TIPC2801KV	8.40
TL026CP	1.84
TL062CN	0.48
TL062CP	0.48
TL064CD	0.98
TL064CN	0.48
TL064ID/SMD	2.10
TL071ACP	1.84

TL071CP	0.48
TL072ACP	1.84
TL072CN	0.50
TL072CP	0.50
TL074ACN	2.85
TL074CN	0.84
TL081CP	0.34
TL082CP	0.36
TL084CN	0.48
TL27L2CD/SMD	1.40
TL497ACN	3.14
TL507CP	4.03
TL7702ACP	2.04
TL7705ACP	2.04
TL7705CP	2.04
TL7709ACP	2.04
TL7770-SC	3.82
TL783CKC	3.06
TLC2201CP	3.06
TLC2202CP	3.06
TLC2274CN	2.85
TLC251CP	2.54
TLC2652CP	4.46
TLC2654CP	4.29
TLC271CP	0.84
TLC272CP	1.30
TLC274CN	2.40
TLC339CN	1.45
TLC372CP	1.40
TLC551CP	3.68
TLC555CP	0.65
TLC556CN	1.14
TLC7524CN	6.86
TLE2061CP	2.20
TLE2062CP	3.40
TLE2064CN	3.45
TLE2161CP	2.42
TMS3477NL	5.96
TPIC2406NE	7.14
TPIC2802KV	8.40
TPIC6259N	3.28
TPIC6273N	3.28
TPIC6595N	3.28
TSC426CPA	POA
TSC500CPE	POA
TSC7106CPL	6.81
TSC7116CPL	5.25
TSC7126CPL	5.35
TSC766OCPA	1.40
U1096B	4.92
U2066B	2.64
U2400B	5.50
U664B	3.95
UA2240PC	1.40
UA709CP	0.85
UA709PC	0.85
UA715HC	4.50
UA723CP	0.70
UA733CJ	2.98
UA741MP	0.60
UA741TC	0.28
UA748CP	0.36
UA748TC	0.52
UA77000UIC	POA
UA798TC	3.80
UCN5800A	2.40
UCN5801A	2.60
UDN2981A	2.00
UDN2982A	2.00
UDN6118A	1.65
UGN3501M	POA

ULN2001AN	0.44
ULN2002A	0.44
ULN2003AN	0.44
ULN2004AN	1.40
ULN2024A	1.40
ULN2032A	1.40
ULN2803AN	0.84
UM5100	POA
UM5101	3.80
XR2211CP	POA
XTR110KP	9.95
Y1112/TI	4.60
ZN1445	POA
ZN414Z	1.04
ZN415E	1.84
ZN423	2.20
ZN425E-8	4.46
ZN426E-8	3.68
ZN428E-8	5.98
ZN429E-8	2.32
ZN449E	4.76

75 SERIES

75107	1.02
75107A	1.02
75108	1.80
75108A	1.84
75108B	2.08
75109A	2.46
75110A	1.36
75113	3.02
75114	3.04
75115	1.60
75116	3.30
75121	2.60
75122	POA
75136	3.10
75138	4.40
75140	2.65
75150	1.60
75150M	2.65
75152	6.36
75154	1.75
75154M	1.75
75155	1.20
75157	4.40
75159	5.45
75160A	5.95
75161A	6.47
75162A	7.59
75172NG	3.68
75173	3.68
75174	3.20
75174NG	3.68
75175	2.60
75176A	1.60
75176B	2.28
75176BT	4.98
75177	2.60
75178	2.60
75182	2.60
75183	2.60
75188	0.40
75189	0.85
75189A	0.85
75361	2.84
75365	2.72
75437A	3.26
75450B	0.64
75451	0.28
75451B	0.48
75452	0.28
75452B	0.48
75453	0.64
75453B	0.64
75454	0.64
75454B	0.98
75462	0.98
75463	1.10
75468	3.60
75469	1.30
75470	POA
75471	1.68
75472	1.48
75473	1.48
75474	2.25
75477	2.10
75491	0.68
75ALS176	2.88
75ALS192	2.88
75ALS193J	3.22
75C1154	2.88
75C1406	2.73
75C185	3.98
75C188	1.20
75C189A	1.32
75C189AD	1.32
75LBC176	2.60

TRANSISTORS THYRISTORS & TRIACS

2N2219A	0.28
2N2222	0.28
2N2222A	0.20
2N2369	0.24
2N2369A	0.20
2N2484	0.32
2N2894	0.78
2N2905	0.29
2N2905A	0.32
2N2907	0.27
2N2907A	0.30
2N2923	0.30
2N2243	0.78
2N3053	0.32
2N3055	0.76
2N3441	1.20
2N3553	0.98
2N3684	1.68
2N3702	0.10
2N3704	0.10
2N3706	0.10
2N3725	0.78
2N3789	2.16
2N3819	0.38
2N3866	1.20
2N3904	0.10
2N3905	0.10
2N3906	0.10
2N3958	2.12
2N4037	0.48
2N405	2.30
2N4062	0.32
2N4091	0.78
2N4123	0.10
2N4124	0.20
2N4125	0.18
2N4126	0.32
2N4221A	2.96
2N4236	3.72
2N4401	0.18
2N4403	0.18
2N4921	1.40
2N5401	0.13
2N5415	0.72
2N5449	0.88
2N5459	0.52
2N5485	0.48
2N5876	1.32
2N6034	0.72
2N6037	0.72
2N6050	3.12
2N6051	3.49
2N6054	2.20
2N6056	1.94
2N6057	2.24
2N6058	2.68
2N6109	0.78
2N6125	2.88
2N6388	0.98
2N6517	0.34
2N6519	0.34
2N6668	1.40
2N696	0.26
2N706A	0.48
2SA1015	0.10
2SA1048/O	0.14
2SA1048Y	0.14
2SA1096R	0.74
2SA1100	0.52
2SA1102	2.10
2SA1104	2.10
2SA1111	1.18
2SA1115	0.80
2SA1145	0.80
2SA1263N	1.70
2SA1264N	2.80
2SA1265N	2.76
2SA1283	0.24
2SA1295	2.76
2SA1302	3.74
2SA1399	0.78
2SA1482	0.78
2SA1515	0.78
2SA1516	3.72
2SA156	1.40
2SA235	1.60
2SA485	1.80
2SA545	0.78

IC SOCKETS LOW PROFILE

No. of Pins	Pin spac-ing	Gold Turn Pin	Tin sldr Tail	Gold sldr Tail
6	0.3	18p	6p	18p
8	0.3	18p	6p	18p
14	0.3	31p	8p	31p
16	0.3	33p	10p	33p
18	0.3	39p	11p	39p
20	0.3	45p	12p	45p
22	0.3	54p	14p	
24	0.3	54p	14p	
24	0.6	54p	14p	
28	0.6	60p	16p	
32	0.6	65p	22p	
40	0.6	70p	22p	
48	0.6	85p		
64	0.75	260p		
64	0.9	260p		

PERSONAL COMPUTER - HARDWARE& SOFTWARE

MOTHER BOARDS

Processor Intel	Bus	Chip Set	BIOS	Cache RAM	Expend Memory	Expension Slots	BoardSize in mm	Pirce £ p
80486DX2-66	ISA	SIS	AMI	256K	32MB	6x16bit,1x8bit	245 x 220	499.00
80486DX2-66	ISA	ALI	AMI	256K	32MB	5x16bit,2x8bit	220 x 220	490.00
80486DX-50	ISA	SIS	AMI	256K	32MB	6x16bit,1x8bit	245 x 220	450.00
80486DX-50	ISA	ALI	AMI	256K	32MB	5x16bit,2x8bit	220 x 220	444.00
80486DX-33	ISA	SIS	AMI	256K	32MB	6x16bit,1x8bit	245 x 220	349.00
80486DX-33	ISA	ALI	AMI	256K	32MB	5x16bit,2x8bit	220 x 220	325.00
80486SX-25	ISA	SIS	AMI	128K	32MB	6x16bit,1x8bit	245 x 220	220.00
80386DX-40	ISA	SIS	AMI	64K	16MB	6x16bit,1x8bit	220 x 220	128.00
80386SX-33	ISA	SIS	AMI	0K	16MB	6x16bit,1x8bit	220 x 220	79.00
80486DX2-66	VESA	SIS	AMI	256K	32MB	7x16(AT),2x32(VESA)	260 x 220	510.00
80486DX-50	VESA	SIS	AMI	256K	32MB	7x16(AT),2x32(VESA)	260 x 220	470.00
80486DX-33	VESA	SIS	AMI	256K	32MB	7x16(AT),2x32(VESA)	260 x 220	349.00

All Mother Boards are supplied with Zero K bytes of RAM. Add £28 per MegaByte of RAM.

CONNER HARD DISK DRIVES

CP-30104E	120MB	19msec 3.5" LP	£189.00
CP-30174E	170MB	19msec 3.5" LP	£219.00
CP-30344	343MB	13msec 3.5" LP	£575.00

QUANTUM HARD DISK DRIVE

ELS-170	170MB	17msec 3.5"LP	£170.00

FLOPPY DISK DRIVES

TEAC	FD-235HF	1.44MB 3.5"	£35.00
TEAC	*FD-55GFR*	*1.2MB 5.25"*	*£39.00*
TEAC	FD-505	3.5"+ 5.25"	£99.00
MITSUMI	D359T3	1.44MB 3.5"	£35.00
MITSUMI	D509V3	1.2MB 5.25"	£32.00
MITSUBISHI	MF355C/258MG	1.44MB 3.5"	£29.00
MITSUBISHI	MF504C/318MP	1.2MB 5.25"	£35.00
CANON	MD5501-V6	3.5"+5.25"	£99.00

FLOPPY DISKS

MANUF.	3.5"/1.44MB	5.25"/1.2MB
TDK	£ 10.65	£ 7.45
SONY	£ 10.10	£ 7.65
FUJI	£ 10.10	£ 7.65
MITSUBISHI	£ 10.70	£ 7.00
UNBRANDED	£ 6.50	£ 4.50

Price per Box of 10 Disks

GRAPHIC CARDS

TRIDENT	TVGA 8900	Trident 1MB SVGA	£41.00
TRIDENT	TVGA 8900CL	New Trident 1MB SVGA	£44.00
CIRRUS LOGIC	XXXX	1MB SVGA	£52.00
TSENG LAB	ET-4000	1MB SVGA	£60.00
METHEUS	Premier 1280 NI	New Premier S3	£299.00
METHEUS	Premier 1M	TSENG LABS ET4000	£240.00

KEYBOARD & MICE

MITSUMI	KPQ-E99YC	102 UK KeyBoard, Regular Size	£20.00
MITSUMI	KPQ-E99AC	102 UK KeyBoard, Space Saver	£20.00
BTC	7849R	102 UK KeyBoard, Regular Size	£24.00
MSI	SYSTEM MOUSE 3 Button Serial		£10.00

I/O CARDS

I/O	2S/1P/1G with cables	£10.00
IDE	2HD/2FD with cables	£10.00
IDE	2HD/2FD/2S/1P/1G/512kB with cables	£15.00
IDE99/512k	CACHE Controller, 2MB RAM, Max 8.5MB	£89.00
IDE99/2.5MB	CACHE Controller, 2.5MB RAM, Max 8.5MB	£125.00

MICROPROCESSORS

80286-16MHz	INTEL	£65.00
80386DX-40MHz	AMD	£75.00
80486SX-25MHz	INTEL	£125.00
80486DX-33MHz	INTEL	£275.00
80486DX-50MHz	INTEL	£375.00
80486DX2-66MHz	INTEL	£350.00

CO-PROCESSORS

80287-8	INTEL	£40.00
80287-10	INTEL	£48.00
80287-XL	INTEL	£65.00
80387DX-33MHz	INTEL	£65.00

MEMORIES

SIMM 1Mx9x9 CHIP 70ns	£28.00
SIMM 1Mx9x3 CHIP 70ns	£29.00
SIMM 4Mx9x9 CHIP 70ns	£107.00
SIMM 4Mx9x3 CHIP 70ns	£107.00
SIMM 256Kx9 CHIP 8Ons	£10.00

SOFTWARE

MICROSOFT ORIGINAL

MS DOS 5	£40.00
MS DOS 5/WINDOWS 3.1	£82.00
MS DOS 6	P.O.A.

IMPORTANT

All prices quoted are Excluding V.A.T.

Postage & Packing Charge of £3.00 is applicable to all goods under the heading of 'Personal Computer Hardware & Software'.

Postage & Packing will be charged at cost for *all* destinations outside the United Kingdom.

PLEASE SEE PREVIOUS ISSUES FOR OTHER ITEMS & FEB/MAR 1992 ISSUES FOR LEDs,DISPLAYS & RELAYS.

VIEWCOM ELECTRONICS

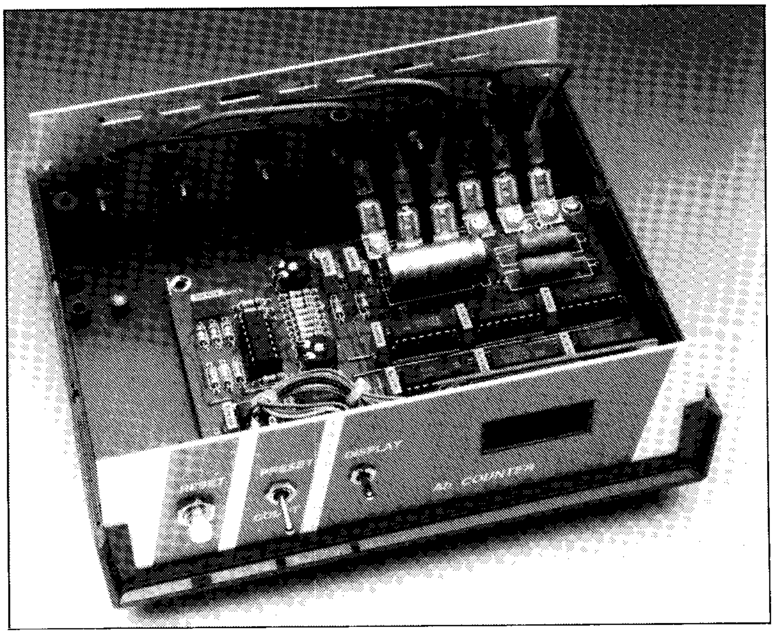
77 UPPERTON ROAD WEST
PLAISTOW, LONDON E13 9LT

PLEASE PHONE/WRITE FOR ITEMS NOT LISTED

PLEASE ADD 95p P & P and then 17.5% VAT. OFFICIAL ORDERS from Govt. & Educational Establishments are accepted. VAT at 17.5% is chargeable to all orders received from EC Member Countries unless VAT Number is quoted. OVERSEAS orders, postage AIR/SURFACE will be charged at cost. VAT is not applicable for EXPORT orders from Non-EC Member Countries. Stock items by return of post. N.B. *All prices are subject to change without notice & stock availability.*

Retail Shop: 139, New City Road, Plaistow, London E13 9PX

Ah METER WITH DIGITAL DISPLAY



Design by K. Bachun

Knowing the current drawn (by a battery) or generated (by a solar cell) over a period of time is a requirement in many applications that can be met with the meter described in this article.

The product of current and time is a measure of the electric charge that has been transported in a circuit. It is usually measured in ampere hours (Ah = 3600 coulomb). It must not be confused with power, which is a product of current and voltage. An instrument that measures ampere hours is of interest, for example, in assessing the effectiveness of a solar battery. Normally, it is not accurately known how much charge the solar cells generate nor how much the load connected to the battery needs. The present meter can become a permanent part of such a setup or be used in the design stage to measure both quantities. It indicates these on a three-digit LED display.

Principle of measurement

The principle of operation is shown in the block diagram of **Fig. 1**. A low value resistor has been introduced in the circuit between the solar cell and battery charged by this cell. The potential drop (pd) across this resistor caused by the charging current (from the solar cell) or the discharge current (through the load) is evaluated by the Ah meter.

The pd is applied to two differential amplifiers, whose output voltages would be equal but 180° out of phase (that is, inverted with respect to one another), if the input were not a simple supply voltage. Thus, the adder amplifies only one voltage; the other (which, with a symmetrical supply, would be negative) is nil. The output of the non-reactive adder is, therefore, a voltage that is proportional to the current and which is used to drive a voltage-controlled oscillator (VCO – also called voltage-to-frequency converter).

The VCO generates rectangular pulses whose frequency is proportional to the current. The pulses are divided andcounted, and then used to drive an LED display.

Since the polarity of the drop across the shunt resistor shows whether the pd is caused by a charging current or a discharge current. the output of a differential amplifier also shows the direction of the current. The output can thus be used to indicate the direction of counting. When energy is drawn from the battery, the counter counts downward; when the battery is being charged by the solar cell, it counts upward.

The meter does not in any way control or affect the charging current; this can be done only by a special solar charging regulator.

The display does not show the state of charge of the battery to the nearest millampere second, since self dicharge and temperature dependence of the battery are not taken into account.

The circuit

The battery, solar cell and load are connected to the circuit in **Fig. 3** by heavy duty connectors. The shunt resistor between battery and cell is formed by two parallel power resistors, R_{46}-R_{54}. If the maximum value of the current is assumed to be 10 A, the drop across the shunt resistor is 0.5 V. If the value of the shunt resistor were higher, the drop would be unacceptably

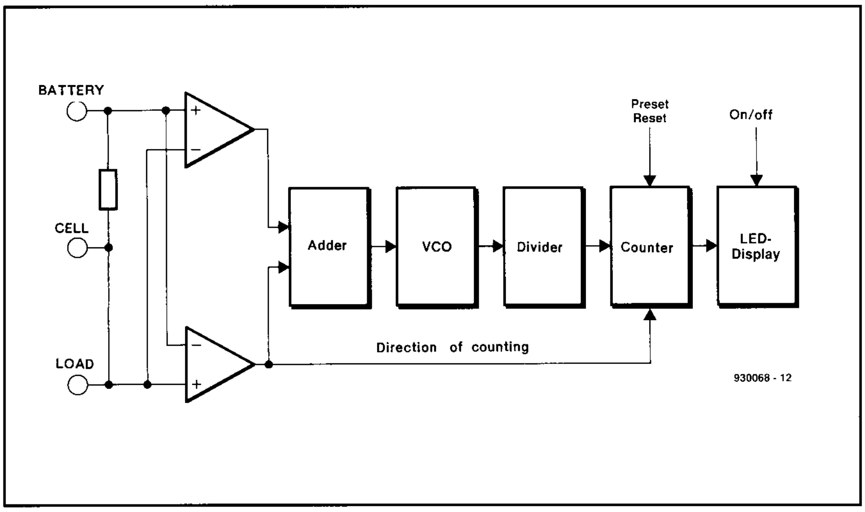


Fig. 1. Block diagram of the Ah meter.

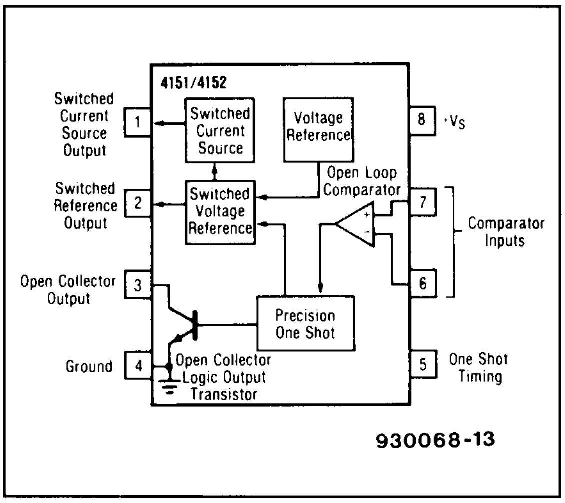


Fig. 2. Circuit of the RC4151 (IC_8).

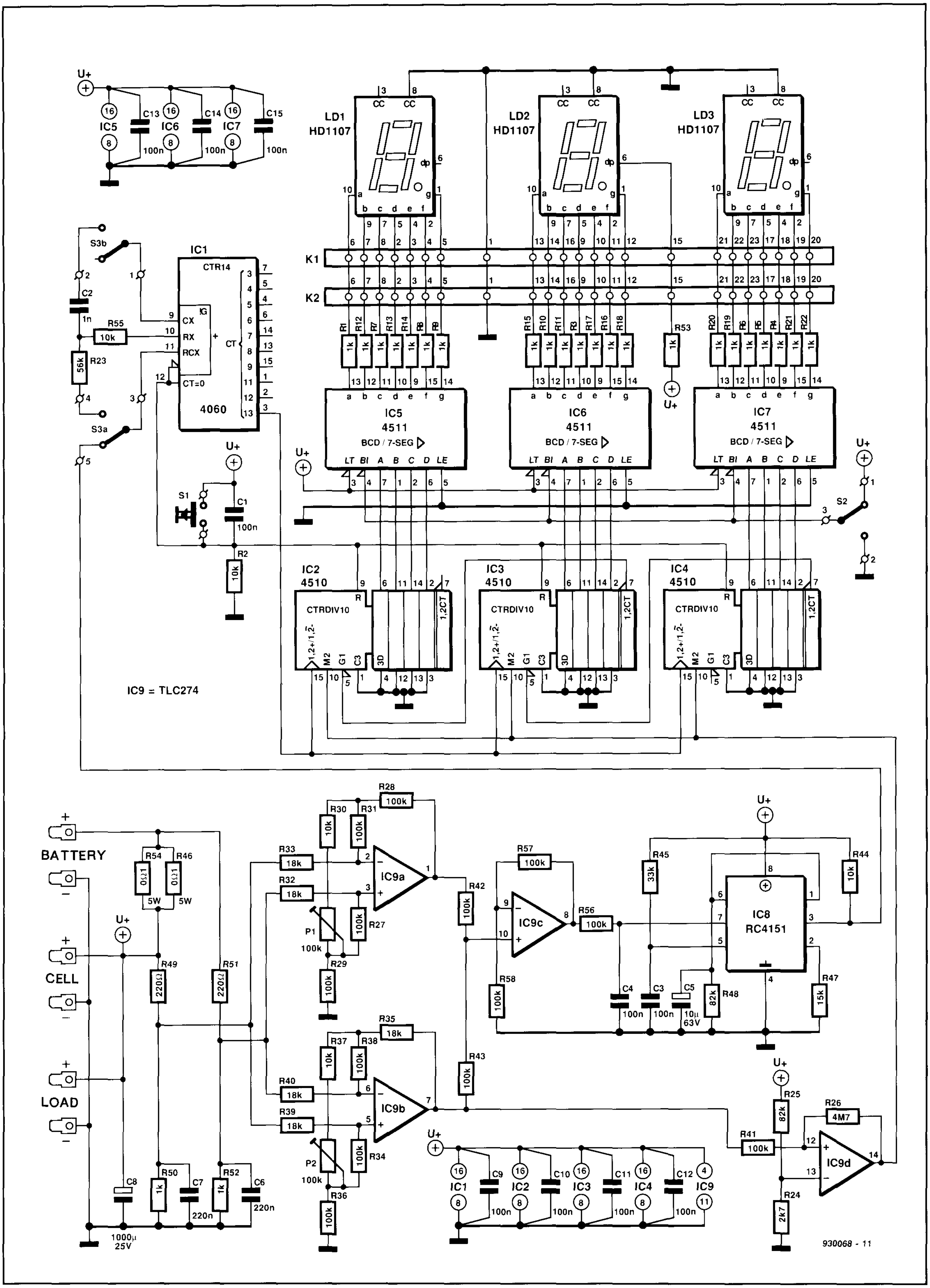


Fig. 3. Circuit diagram of the Ah meter.

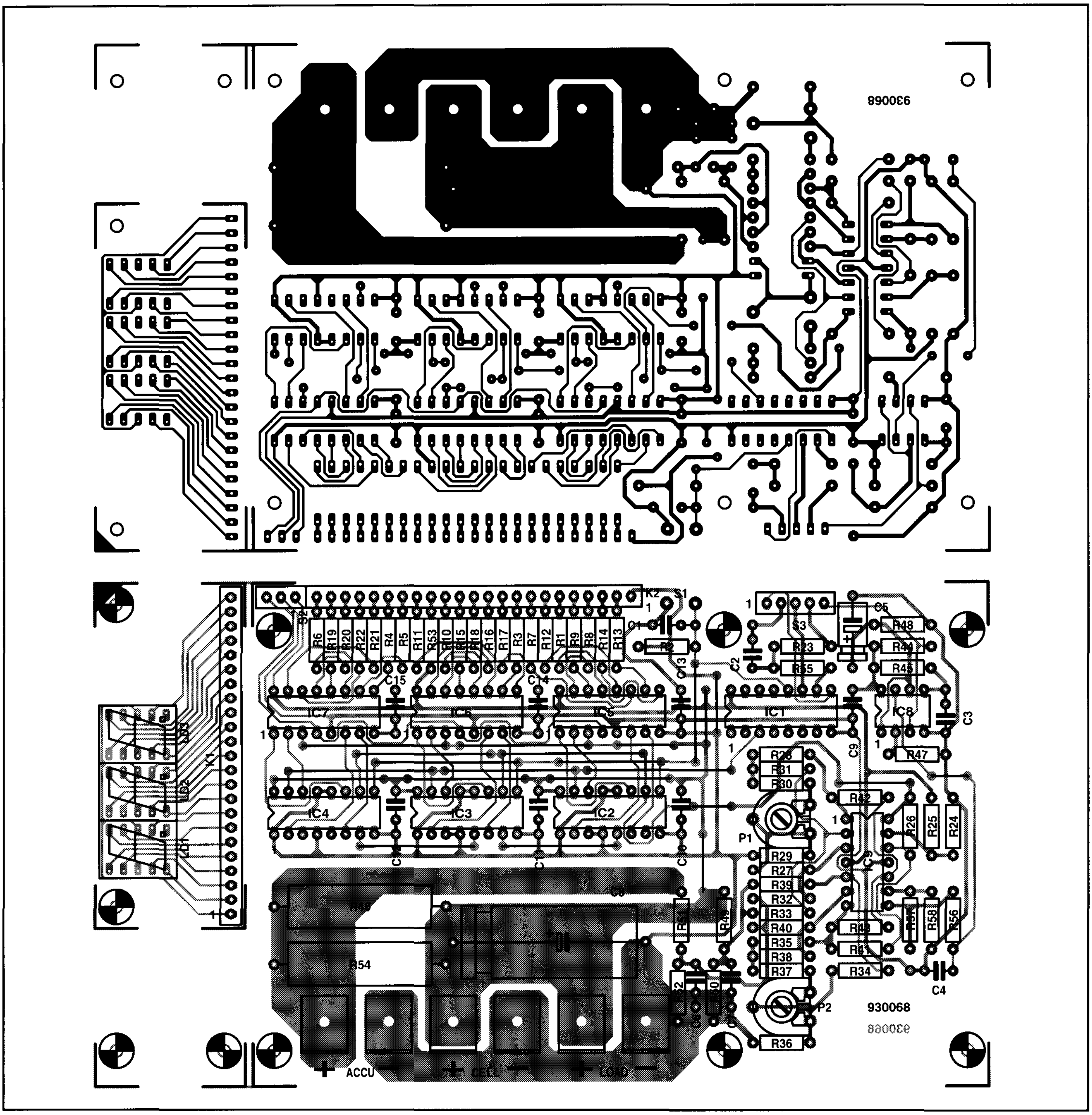


Fig. 4. Printed-circuit board for the Ah meter.

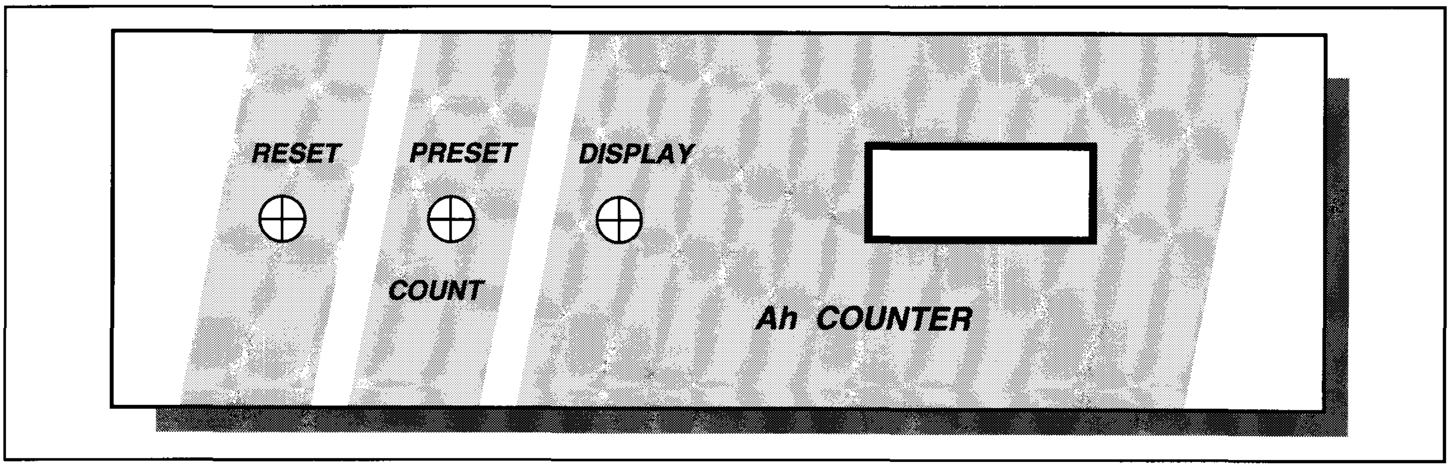


Fig. 5. Front panel foil for the Ah meter (see page 70).

high.

Potential dividers R_{49}-R_{50} and R_{51}-R_{52} reduce the common-mode voltage by about a fifth, so that the unregulated supply voltage which the meter draws from the battery or solar cell is always a little higher than the input voltage at one of the differential amplifiers. If the supply voltage is regulated, it is imperative that the differential input voltage, which in the present design is only four fifths of the drop across R_{46}-R_{54}, that is, not more than 400 mV, cannot exceed the common-mode range of the opamps.

The accuracy of the measurement is not affected by the variable supply voltage, as long as this lies within the usual range of 10-14 V. By the way, the Ah meter cannot be used with 24 V cells and batteries.

Capacitor C_8 smooths the charging and supply voltages so that voltage peaks cannot cause spurious measurements. Capacitors C_6 and C_7 short out any short spurious pulses at the inputs of the operational amplifiers.

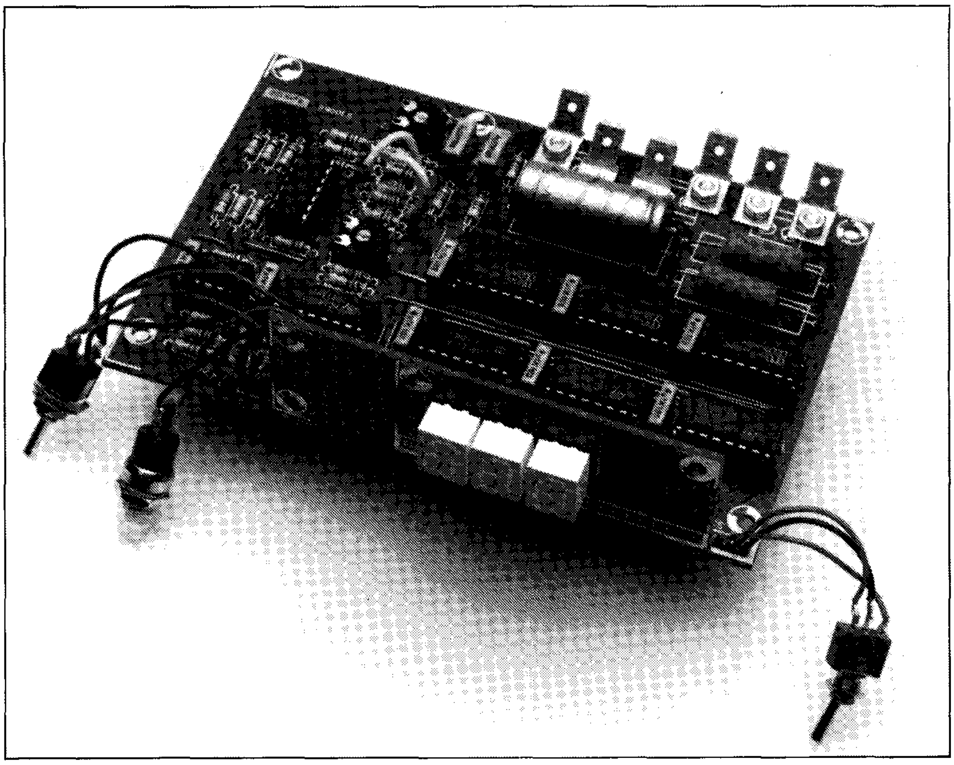


Fig. 6. Completed prototype without enclosure.

PARTS LIST

Resistors:
R_1, R_3–R_{22}, R_{53} = 1 kΩ
R_2, R_{30}, R_{37}, R_{44}, R_{50}, R_{52}, R_{55} = 10 kΩ
R_{23} = 56 kΩ
R_{24} = 2.7 kΩ
R_{25} = 22 kΩ
R_{26}–R_{29}, R_{31}, R_{34}–R_{36}, R_{38}, R_{41}–R_{43}, R_{56}–R_{58} = 100 kΩ
R_{32}, R_{33}, R_{39}, R_{40} = 18 kΩ
R_{45} = 33 kΩ
R_{46}, R_{54} = 0.1 Ω, 5 W
R_{47} = 15 kΩ
R_{48} = 82 kΩ
R_{49}, R_{51} = 2.2 kΩ
P_1, P_2 = 100 kΩ preset potentiometer

Capacitors:
C_1, C_3, C_4, C_9–C_{15} = 100 nF
C_2 = 1 nF
C_5 = 10 µF, 63 V
C_6, C_7 = 220 nF
C_8 = 1000 µF, 25 V

Integrated circuits:
IC_1 = 4060
IC_2–IC_4 = 4510
IC_5–IC_7 = 4511
IC_8 = RC4151 (Raytheon)
IC_9 = TLC274

Miscellaneous:
S_1 = SPST switch
S_2 = spring-loaded, press-to-make switch
S_3 = double-pole, change-over switch
LD_1–LD_3 = HD1107
6 off 10 A, banana socket for chassis mounting*
6 off car-type spade terminal (male and female) for PCB mounting*
2 off 23-way terminal strip, male
Enclosure, as required
PCB No. 930068 (see p. 70)
Front panel foil No. 930068F (page 70)

* either of these are required, see text.

The design of the differential amplifiers is traditional. Their amplification is about ×20, which gives a peak output voltage of around 8 V. The value of the resistors at the non-inverting inputs corresponds to that of the resistors at the inverting inputs. The common-mode rejection of a differential amplifier relies on the equality of these resistors. To avoid the necessity of costly close-tolerance resistors, the amplification factors can be adjusted with P_1 and P_2. This also serves another function. It is well known that a battery must be charged with 40% more energy than can be drawn from it. If, for instance, it has been charged with a quantity of electricity of 1 Ah, only 715 mAh can be drawn from it. This means that the amplification of IC_{9a} must be 1.4 times as large as that of IC_{9b}.

As explained earlier, the polarity of the drop across the shunt resistor causes IC_{9a} to amplify when the battery is being discharged, and IC_{9b} when the battery is being charged. The output of the non-amplifying opamp is 0 V. Since both outputs are connected to the high-impedance, non-inverting (+) input of IC_{9c}, potential divider R_{42}-R_{43} functions as if it were connected to ground. This means that the amplification of IC_{9c} is ×2.

The output of IC_{9b} is also applied to Schmitt trigger IC_{9d}. As soon as the output of IC_{9b} reaches a certain level, IC_{9d} changes state (goes high). The output of IC_{9d} determines the direction of counting of IC_2–IC_4.

Reverting to the output of IC_{9c}, this voltage, which is directly proportional to the charging/discharge current, is applied to voltage-controlled oscillator (VCO) IC_8—see **Fig. 2**. The output of the comparator in this circuit drives a monostable multivibrator (MMV), which in its turn controls the switched current source, the switched voltage reference and the open-collector logic output transistor. When the voltage at pin 7 of IC_8 exceeds that at pin 6, the comparator changes state and triggers the MMV. This stage then enables the current source, the voltage reference and the output transistor. It operates basically in the same way as the well-known Type 555 timer, in that it charges a capacitor (C_3), which is connected to *U*+ via R_{45}. The capacitor voltage is monitored at pin 5; as soon as this reaches 67% of the supply voltage, the mono time is terminated, upon which the capacitor is discharged immediately via a transistor.

During the mono time, the current source provides a current at pin 1 that is directly proportional to the reference voltage and external resistor R_{47}. The switched voltage reference provides a potential of 1.9 V at pin 2, which is equal to fixed internal reference voltage. The open-collector transistor connects the output (pin 3) to ground. In other words, during the mono times, the switched voltage reference generates a positive voltage pulse; the current source generates a current pulse that is well defined in duration and amplitude; and the output transistor has transmitted a logic pulse that is compatible with most logic cards. All these signals are directly pro-

SPECIAL OFFERS WHILE STOCKS LAST

COMPONENTS

80C31 44pin SMD CPU **£1.25** 82C55 PIA **£1.45** 8749 Eprom CPU **£5.00**
LM358 OpAmp **£1.00** for 5 6264 RAM **£2.00** UAA2050T UHF pager **£6.00**
24pin Zif **£1.25** 24pin Dil IDC header **£1.00** for 3 Submin MicroSwitch 3 Amp **£100** for 6
7 Seg display CA RED (FND500) .... **£1.00** for 4
Rotary Switch 1 Pole 12way or 3 pole 4way .... **£1.50** for 5 (either type)

PC SCOPE Turn your IBM PC into a powerful Storage Oscilloscope, Digital Voltmeter or Sound Sampler. Converter plugs into printer port with no power required. The A/D converter with software (VGA required) ready to plug in and go. .... **Only £29.95**

ASM51 + SIM51 Complete Text Editor /Assembler plus Simulator for Microcontrollers 8051/52. Runs on IBM PC. Full control Registers & memory. Label generated disassembly, program trace, single-step, go with break many more features **£19.95**

ASM48 + SIM48 As above but for 8048/49 controllers **£19.95**

EPROM/ROM EMULATOR Works with **ANY** computer with centronics printer port. Emulates all ROMs from 1k(2758) to 32k(27256) over 50 types supported. Any file sent to printer port appears as ROM on target machine. Fast download. Ideal for MICRO development. **£39.95**

PLEASE ADD £1.50 POST & PACKING

JOHN MORRISON (MICROS) DEPT ET
4 REIN GARDENS, TINGLEY, WEST YORKSHIRE,
WF3 1JR. TELEPHONE 0532 537 507

ACCESS VISA

BADGER BOARDS

Printed Circuit Boards for Amateur Radio Schools Colleges Short Wave Listeners Clubs Hobbyists & Industry

A range of Printed Circuit Boards in stock from many of the Projects in Magazines
PRACTICAL WIRELESS ❑ SHORT WAVE MAGAZINE ❑ ELEKTOR❑ HRT RADIO COMMUNICATION
Kits Projects and Materials for manufacturing your own boards. Artwork and Plotting from your own Schematic drawings and also C.A.D. facilities. We supply ONE OFF Prototypes
Phone between **9.00am and 5.30pm Monday to Friday** for helpful advice and assistance
Club talks and demonstrations of Printed Circuit Board manufacture QRP involvement etc

021-353 9326

87, Blackberry Lane, Four Oaks, Sutton Coldfield. B74 4JF
(Please mention where you spotted this advertisement)

portional to the level of the input voltage. When the mono time elapses, these three functions are disabled.

Circuit IC_8 operates here in a standard application. The output of IC_{9c} is applied to the non-inverting input of the comparator (pin 7) via a low-pass filter, R_{56}-C_4. The MMV operates as an oscillator since it is continuously triggered by the common-mode input voltage. The current source provides a current of $U_{ref}/R_{47} = 40\ \mu A$ for a time $1.1 \cdot R_{45} \cdot C_3 = 3.63$ ms into integrating network R_{48}-C_5. Critical is the feedback of the integrator to the inverting input of the comparator (pin 6), which raises the pulse repetition rate until the average potential across the integrator is equal to the common-mode voltage at pin 7. The average voltage at pin 6 is directly proportional to the output frequency (and that at the open-collector output) since the quantity of charge in each current pulse is accurately controlled. In other words, the output frequency is directly proportional to the input voltage.

The external components determine the design parameters. The time constant of the output signal is the product of the mono time, the amplitude of the output current at pin 1, and the reciprocal of the current through the integrating resistor. From this, the formula for the output frequency, f_0 is

$$f_0 = (U_{ref} / R_{47} \cdot R_{48} / U_{in} \cdot 1.1 \cdot R_{45} \cdot C_3)^{-1}.$$

With component values as specified, this yields an output frequency of 212 Hz. This will be reverted to later on.

If any component values are altered, it should be noted that the value of R_{47} must be between 12 kΩ and 20 kΩ. Also, because of the offset of the operational amplifier, it is not possible to obtain an input voltage of exactly 0 V. It does not pay to compensate the offset, because IC_8 in its standard configuration operates correctly only from 10 mV onward in any case. The consequent error of 2 Hz (equivalent to <1% of full-scale deflection) is negligible compared with, for instance, that caused by the self discharge of the battery.

The output of the voltage-to-frequency converter is applied to divider IC_1 via switch S_3. Divided by 2^{13}, it is output at pin 13 and applied to cascaded CARRY OUT / CARRY IN binary-coded decimal (BCD) counters IC_2–IC_4. Pressing S_1 sets the counters (and the divider) to 0. Note that R_{23}, R_{55}, and C_2 serve no useful function in normal operation.

The counting direction inputs of IC_2–IC_4 are driven by IC_{9d}. Note that the preset inputs are not used. The outputs of the counters are fed to BCD-to-7-segment decoders IC_5–IC_7. The decoders control the 7-segment LED displays LD_1–LD_3.

During normal operation, the displays are not on, since the Bl(anking) inputs of the decoders are at ground potential via S_2. It is advisable to use a spring-loaded switch here, so that the display cannot be left on inadvertently. Note that the right-hand decimal point is always on, however, to show that the meter is functioning.

To ensure that the display increases from 00·0 to 10·0 when a constant current of 10 A has flown for 1 hour, the counters need 100 pulses per hour or 100/3600 pulses per second. This means that the VCO must generate a signal at a frequency of $100/3600 \cdot 2^{13} = 227.56$ Hz. Working back, this means that the VCO needs an input of 8.58 V. Since the differential input voltage is fairly accurately 410 mV when a current of 10 A flows through the shunt resistor, the differential amplifier must have an amplification of $8.58 / 0.41 = 20.9$.

Owing to component tolerances and other imponderables, the potentiometers should be preset empirically. This is done by connecting the positive output of an accurate 500 mV source to the '+ battery' terminal, and the negative output to the '+ cell' terminal. Turn P_2 until a frequency counter at the output of (pin 3) of IC_8 shows 228 Hz. Then reverse the connections of the voltage source and adjust P_1 until the display reads $1 / 1.4 \cdot 228 = 163$ Hz.

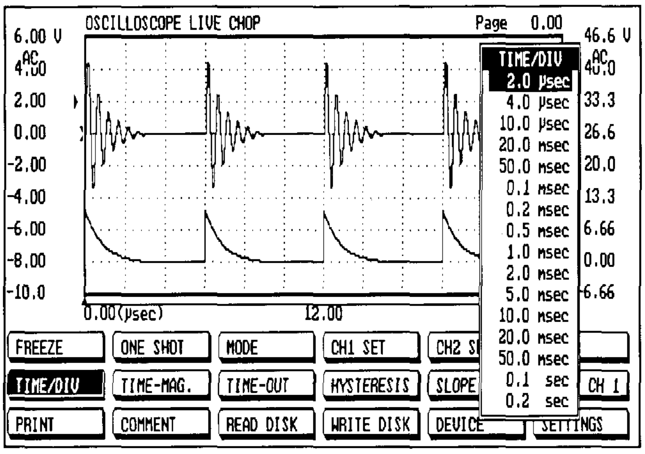
The display is checked by switching into circuit (with S_3) components R_{23}, R_{55}, and C_2. This actuates an *RC* oscillator in IC_1. If everything is all right, the display will fairly quickly give a high reading. This position of S_3 is also for presetting a given counter state when, for instance, the Ah meter is connected to a fully charged battery.

Construction

The printed-circuit board in **Fig. 4** can, if desired, be cut into two to enable the displays to be mounted at an angle behind the front panel. Otherwise, fit them in IC sockets so that they protrude above the other components. The 23-way terminal strips, K_1 and K_2, must be used in both cases.

Use car-type insulated spade terminals (male and female) for 'battery', 'cell' and 'load'. If, however, the meter is given its own enclosure, use the 10 A chassis-mounted banana sockets specified in the parts list. **END**

DATA ACQUISITION WITH THE PC



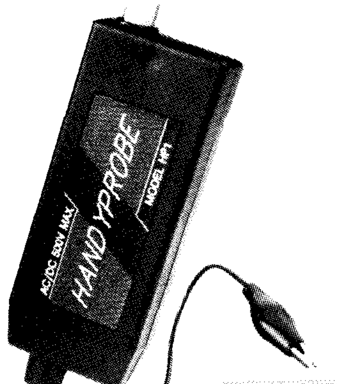
TiePie engineering manufactures a complete range of computer-controlled measuring instruments. Connecting these units to a PC (MS DOS 3.0 or higher) *results in a number of compre*hensive test instruments:

- oscilloscope;
- voltmeter;
- spectrum analyzer;
- frequency meter;
- transient recorder.

All measured data can be stored on disk or run off for documentation. Because of the many trigger possibilities, a variety of signals can be measured, while the powerful software enables a multitude of measurements to be carried out in a straightforward manner. Application areas include: service; medical research; automatic test systems; research and development; and education.

LOW COST: HANDYPROBE

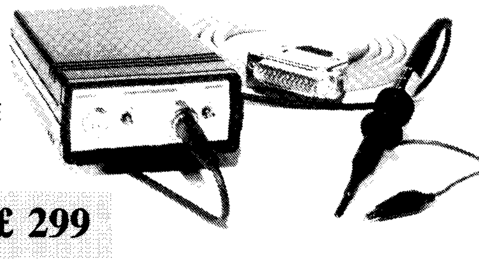
Connect the HANDYPROBE to the parallel printer port of the PC and start the software. Measuring can be carried out at once. The HANDYPROBE does not need an external power supply. Some technical parameters: 0.5-400 V software select input range; one input channel; 8 bits resolution (overall accuracy 2%); A complete software program consisting of a digital storage oscilloscope, spectrum analyzer, voltmeter and a *transient recorder* is provided. The HANDYPROBE is eminently suitable for servicing and educational purposes.



£ 99

BEST PERFORMANCE: HANDYSCOPE

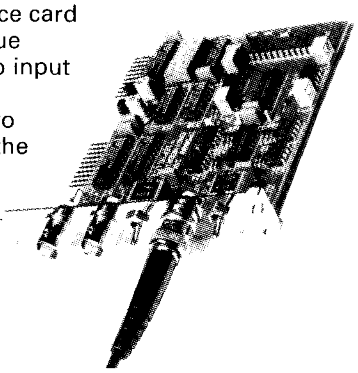
The HANDYSCOPE is connected to the parallel printer port. This makes it possible to carry out measurements with a laptop or notebook PC. Because of its high resolution (12 bits), the HANDYSCOPE is a very accurate instrument. The measuring rate is 100,000 samples/sec. Either of the two channels can be set independently over a range of 0.5-20 V (with a 1:10 probe up to 200 V). The advanced software enables many measurements to be *carried out.* Two probes (switchable 1:1-1:10) are provided. The HANDYSCOPE is constructed as a small table model with two BNC connectors. The length of the cable linking the PC and the HANDYSCOPE is 1.8 m, which can be extended to 3.8 m.



£ 299

MULTIFUNCTIONAL: TP5008

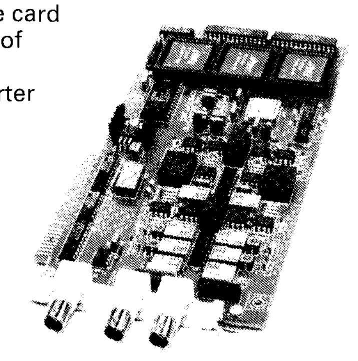
The TP5008 is an interface card that provides an analogue output in addition to two input channels. This output in combination with the two inputs may be used for the setting up of a complete control loop. The output may also be used as a *function generator.* The TP5008 has a resolution of 8 bits and a sampling rate of 200,000 samples/sec (200 kHz). The input range may be set to 0.5-20 V full-scale deflection. The output range covers 1.25-2.5 V. The TP5008 is fitted with BNC connectors and is delivered complete with a user manual and software. Separately available are 1:1-1:10 probes and 1:100 oscilloscope probes.



£ 197

VERY HIGH SPEED: TP208

The TP208 is an interface card with a measuring speed of 2×20 Megasamples/sec (8 bits). Phenomena shorter than one millionth of a second can still be measured well. The completely digitized triggering ensures very *stable triggering with* many trigger possibilities. The TP208 has an input range of 5 mV/div to 20 V/div in 12 steps and an auto calibration function. Since both channels may be sampled simultaneously, phase differences can be measured very accurately. Even single phenomena can be measured since each channel has a 32 KByte memory. Comprehensive software is provided.



£ 595

(All prices are exclusive of VAT and P&P)

Interested? Then write or fax for a FREE demo diskette to

INSTRUTEK (UK)

28 Stephenson Road
Industrial Estate
St Ives, Cambs PE17 4WJ
England

Telephone (0480) 460028
Fax (0480) 461 654

FUZZY LOGIC MULTIMETER
(PART 2)

There is little to say about the true-r.m.s. converter. The circuit diagram (Fig 5) shows a standard application of the AD736JN, connected to a non-critical *R-C* network, C4-R15, and three electrolytic capacitors (also uncritical), C5, C6 and C7. The bandwidth of the true-r.m.s. converter exceeds that of the multimeter IC input by far. In fact, the multimeter IC limits the –1%-bandwidth of the DMM to about 300 Hz. Keep this in mind when measuring signals with a lot of distortion (i.e., containing many higher harmonics), because for the measurement to be accurate, the strongest harmonics have to fall within the 300-Hz bandwidth of the DMM.

The multimeter power supply is relatively simple, consisting essentially of a 5-V regulator, IC10, and an inverter, IC3. Jumpers JP16 and JP17 are remnants of the experimental phase of the circuit, and determine where the analogue and digital ground are interconnected. On the final design of the printed circuit board, JP16 is a

Register Map of Output Data

ADDRESS OR REGISTER NUMBER	REGISTER NAME	REGISTER CONTENTS
0	Ones	Conversion Result BCD data for least significant digit (The undisplayed digit used fot digital autozero)
1	Tens	BCD data of Conversion Result (Least significant displayed digit)
2	Hundreds	BCD Data of Conversion Result
3	Thousands	BCD Data of Conversion Result
4	10 Thousands	BCD Data of Conversion Result
5	Status	D3 Always 1 D2 Latches Continuity $\overline{\mathrm{D1}}$ Holding D0 Low Battery

Register Map of input Data

ADDRESS OR REGISTER NUMBER	D3	D2	D1	D0
0	Hold	High Frequency	Beeper ON	Sleep
1	10^{-0}	Filter Short	÷5	50Hz
2	10^{-4}	10^{-3}	10^{-2}	10^{-1}
3	DC	Ext AC	Divider Sense	Ohms R/2
4	Current	X2	Read Zero	Filter On

BIT SET	VOLTAGE RANGE	OHMS RANGE
10-0	400mV	4M and 40M
10-1	4V	400kΩ
10-2	40V	40kΩ
10-3	400V	4kΩ
10-4	4000V	400Ω

MEASUREMENT RESULT	BCD DATA
+40000	40000
—	—
+00100	00100
—	—
+00001	00001
00000	00000
−00001	99999
—	—
−40000	60000

FILTER ON	FILTER SHORT	FUNCTION
1	0	Normal filter on condition
1	1	Filter on, $R_{FILTER1}$ is bypassed. Use this bit combination to compensate for the higher source impedance of the 4V range.
0	1	Bypasses the Filter.
0	0	Invalid combination, do not use

Table 1. Overview of data contained in the MAX134 registers.

A14 A13	A12 A11 A10	A9 A8 A7 A6 A5 A4 A3	A2 A1 A0	PC address line
R4	R3 K0 - K7		R2 R1 R0	MicroSystem
card register address	card address	PC I/O address	register address MAX134	

R4	R3	R2	R1	R0	read	write
0	0	0	0	0	units	input data (see table 1)
0	0	0	0	1	tens	input data (see table 1)
0	0	0	1	1	hundreds	input data (see table 1)
0	0	1	0	0	thousands	input data (see table 1)
0	0	1	0	1	status	not used
0	1	x	x	x	data IC9	not used
1	0	x	x	x	data IC4	not used
1	1	x	x	x	not used	not used

Table 2. Addressing standard adopted for the MicroSystem bus/DMM card combination.

jumper, and JP17 must never be fitted. That leaves JP14 in the power supply section. JP14, together with JP10 on the PC interface board, selects the source of the supply voltage. The available options are: (1) the computer's 12-V supply, (2) an external 12-V supply connected to K2 on the interface board, or (3) an external power supply connected to the DMM board (between points U_x and 0).

The design of the digital output section is simplicity itself. Data is clocked directly from the databus into two eight-bit registers, IC4 and IC9. The clock signal is supplied by address decoder IC6, which is controlled by register address lines R3 and R4 (more about this further on). Six bits of IC9 are reserved for internal use. The first bit (pin 19), is used as a software-controlled interrupt enable switch. Thus, the interrupt generated by the DMM on completion of the conversion cycle may be blocked (disabled) either by removing JP13, or by setting the first bit in IC9. If this bit is at 0, NAND gate IC5b no longer feeds the EOC (end-of-conversion) signal supplied by IC1 to transistor T1. The second bit is used to control a LED, D6, which forms a 'software activity' indicator and has, strictly speaking, nothing to do with the function of the DMM card. As long as the LED flashes, you are assured that the PC is talking to the DMM card.

The remaining bits in IC9 are all fed to driver IC11, which is capable of handling far more output current than the average HCT gate. Four bits are used to control relays in the multimeter's input circuit. These bits are also suitable for controlling bistable relays, which have two coils. The advantage of a bistable relay is that it has to be energized only to switch over the contacts, which automatically remain in the new position. This means that a bistable relay does not require a constant current to keep its contacts in a certain position. The advantage is obvious: reduced current consumption. Unfortunately bistable relays are still relatively expensive as well as hard to find as one-offs, and that is why normal, monostable, relays appear in the components list. The control software also assumes that monostable relays are used.

The inputs of drivers 7 and 8 in IC11 may be connected in parallel with driver 6 or 5 by fitting jumper JP11 and JP12 respectively in position 'A'. The parallel connection is useful where two lines are always controlled simultaneously under the control of one bit at one address. If jumpers JP11 and JP12 are set to position 'B', drivers 7 and 8 are controlled separately via two bits of IC4.

The DMM chip, IC1, is controlled via latch IC7 and databus buffer IC8. It was already seen from Fig. 4 that the register addresses of IC1 have to be stable quite a while before data can be read or written. This is achieved by the following trick. Each time a register is addressed in IC1 (R2/R4=00_B), address decoder IC6 clocks the register address (R0/R1/R2) in latch IC7. If the desired register address is read first, and the data simply forgotten, the latch will ensure that the address remains stable on the address inputs of IC1. After 3.5 μs, the same register may be addressed again, and data may be read or written.

Address decoder IC6 has a crucial function in the write and read actions to and from the card. It is enabled via the PC interface by the strobe signal and one of the card selection lines en-

COMPONENTS LIST

DMM BOARD

Resistors:

2	1kΩ 0.1%	R1;R5
2	10kΩ 0.1%	R2;R6
1	100kΩ 0.1%	R3
1	1M1 0.1%	R4
2	301kΩ 1%	R7;R8
1	1M2 1%	R9
1	1M 1%	R10
1	10MΩ 1%	R11
1	332kΩ 1%	R12
2	10kΩ	R13;R14
1	22MΩ	R15
2	1Ω5	R16;R21
1	2Ω2	R17
1	1kΩ2	R18
1	2kΩ2	R19
1	1Ω 1%	R20
1	3kΩ3	R22
1	4kΩ22 1%	R23
1	5kΩ11 1%	R24
1	100kΩ multiturn preset	P1

Capacitors:

1	4nF7 MKT	C1
2	22nF	C2;C3
9	100nF	C4;C9;C10; C12;C13;C15; C16;C18;C19
1	33μF 16V radial	C5
5	10μF 16V radial	C6;C7;C8;C17; C25
1	22μF 16V radial	C11
1	10pF	C14
4	100μF 16V radial	C20-C23
1	1pF	C24

Semiconductors:

4	BYV27-100	D1-D4
1	ICL8069C	D5
1	LED, red, high-efficiency	D6
1	BC547B	T1
1	MAX134CPL	IC1
1	AD736JN	IC2
1	ICL7660CPA	IC3
1	74HCT08	IC5
1	74HCT138	IC6
3	74HCT574	IC4;IC7;IC9
1	74HCT245	IC8
1	7805	IC10
1	ULN2803	IC11

Miscellaneous:

1	Passive AC buzzer	Bz1
1	Multifuse 0.4A/50V	F1
1	14-way box header, angled	K1
1	34-way header, angled, side latches	K2
1	PTC max. 2kΩ	PTC1
1	32.768kHz crystal	X1
2	V23042-A1001-B101 relay (Siemens)	Re1;Re2
1	Printed circuit board plus software; order code 920049-1 (see page 70)	

The control software is also available separately: order code 1721 (see page 70)

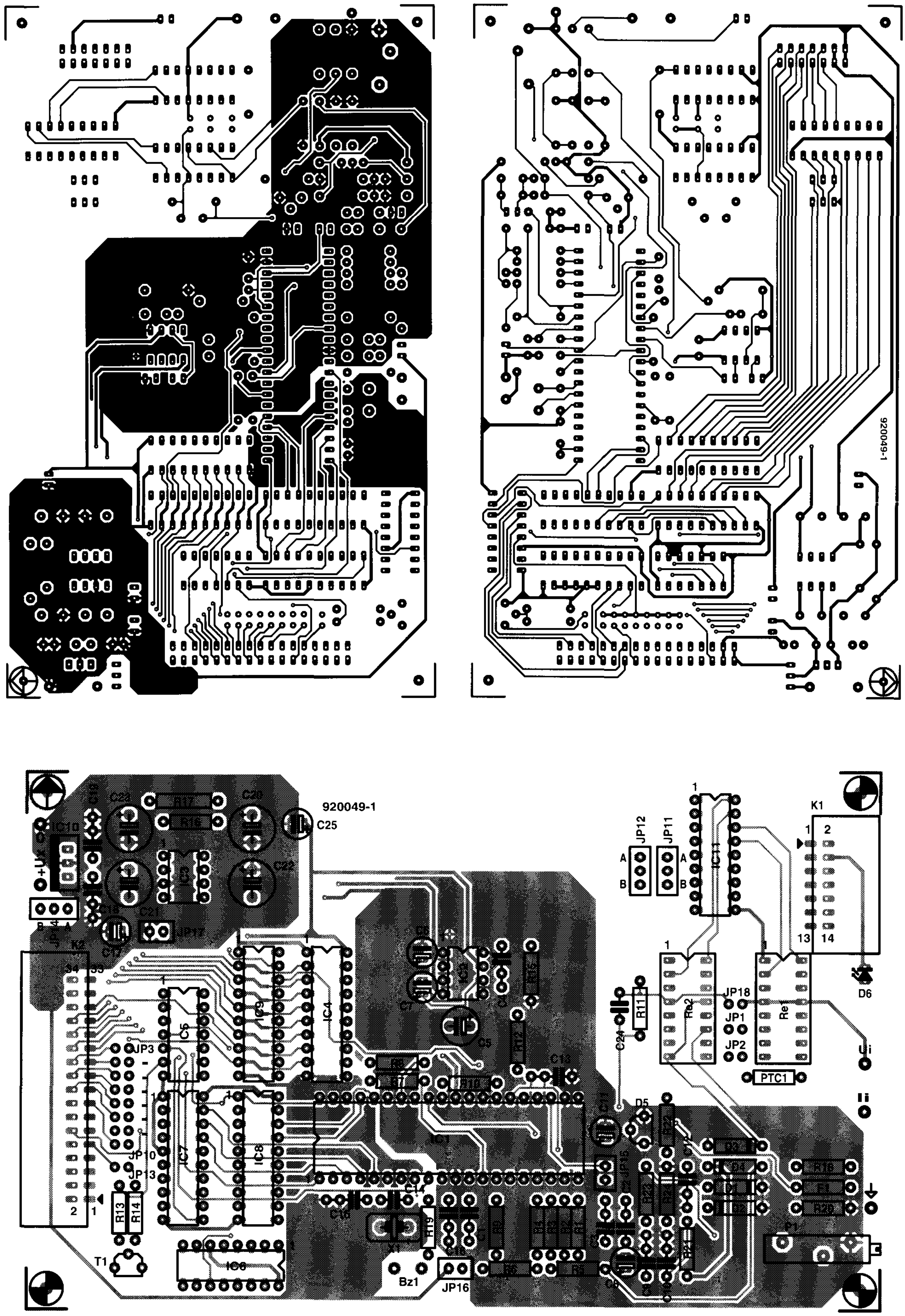


Fig. 6. Track layouts (reduced to 80% of true size) and component mounting plan for the DMM board.

Jumpers/ switches on PC interface card:
Jumpers:
JP1-JP7; JP11-JP14: open (interrupts not used)
JP8: open (no clock required for DMM IC)
JP9: ground (CHRDY on slot = HIGH)

DIP switch S1:
S1-1 - S1-5: on. S1-6: off. Sets card base address to 300H.

Jumpers on DMM card:
JP1: closed
JP2: open
JP3-JP9: open
JP10: closed (DMM = card 0)
JP11: see text
JP12: see text
JP13: open (interrupts not used)
JP14: U_i
JP15: closed (filter effective)
JP16: closed
JP17: open (never close!)
JP18: open

Table 3. Default settings of the jumpers and the DIP switch.

abled via jumpers JP3-JP10. IC6 accomplishes the final addressing with the aid of lines R3, R4 and write. Together with R0, R1 and R2, this gives the addressing shown in Table 2.

The final section of the multimeter circuit to be discussed is the measurement circuit around IC1. The components vital for correct measurement results are resistors R1-R6 and R11, since they determine the resistance and voltage ranges. Unlike R1-R6, R11 is a 1% resistor. A 0.1% type would, of course, be preferred, but proved unobtainable for the value required (10 MΩ). Fortunately, the error (if any) introduced by the higher tolerance on R11 is compensated by calibration preset P1. Tolerance compensation is not available for R1-R6, so any deviation from the stated resistance values causes inevitable differences between the ranges. These differences are kept to a minimum by using 0.1% resistors.

Nearly all switches required for switching between the various ranges are available in IC1. There is, however, one exception. To be able to use the meter as an ohmmeter, the input circuit has to be modified. Junction R1-R2-R5-R6 is usually connected to ground via relay contact Re2. For resistance measurements, R11 has be connected to this junction also. This is achieved by energizing Re2. The junction is then also connected to the 400-mV input of IC1 via PTC1. Together with diodes D3 and D4, the PTC protects the ohmmeter against high voltages (sparks and discharges) at the input terminals. To make sure that the PTC can not affect the lowest resistance range, its value may not be smaller than 2 kΩ under normal circumstances. Finally, for resistance measurements, input terminal U_i has to be connected to the 400-mV input. This is accomplished by relay Re1, which is also used to connect Ui to the 400-mV input to create the 400-mV range of the multimeter. Jumpers JP1 and JP2 are intended to adapt the input circuit to different types of relay. In most cases, JP1 will be fitted. Jumper JP18 allows relays Re1 and Re2 to be shunted (in which case the relays may be omitted), which forfeits the resistance measurement function of the DMM, leaving the current and voltage (both AC and DC) only. Omitting the ohmmeter function is an option where resistance measurements are not required anyway.

Construction

The artwork for the DMM board (double-sided, through plated) is shown in Fig. 6. Like the PC interface card, this board is available ready-made through the Readers Services. Although construction is straightforward, great attention should be paid to neat and accurate solder work. Remember, one bad solder joint at a crucial point may reduce the accuracy of the meter considerably.

Important notice: although the DMM IC has a 4,000-V range, the printed circuit board is **not** suitable for such a high voltage. This range is, therefore, not available in software. If you write your own software for this circuit, you must not attempt to use the 4,000-V range. The PCB can withstand the mains voltage (220 or 240 V), but always check if the ground of the PC is separated from the mains earth. If the two are connected, swapping the live and neutral lines, although unlikely given their fixed positions on UK style mains plugs and sockets, may cause a short-circuit with disastrous results.

For the time being, preset P1 may be set to the centre of its travel. If you wish, you may want to adjust it for 655 mV measured with a voltmeter. However, before you can start testing the two boards, make the bus cable, and fit the jumpers. The standard jumper settings are given in Table 3. Settings other than the ones shown must be communicated to the program (this is explained in the help texts).

The construction of the 34-way flatcable is simple — see Fig. 7. Although a maximum length of 1 m is indicated, our prototypes gave no problems with cables of up to 1.5 m long. Both cable ends are fitted with an IDC (insulation displacement) socket. If you intend to use more than one DMM card, additional sockets may be pressed on to the cable as illustrated in Fig. 7. The distance between the sockets should be about 6 cm. Finally, check the continuity of all 34 connections.

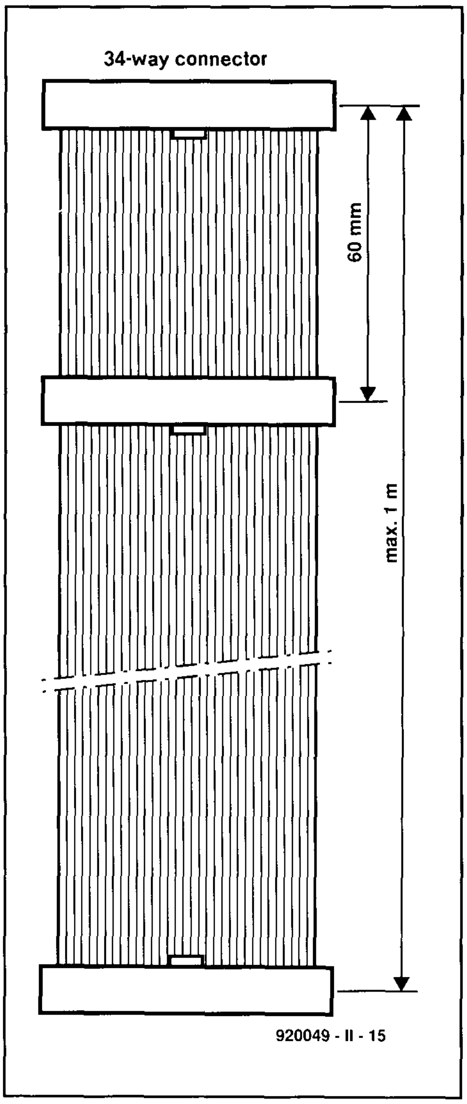
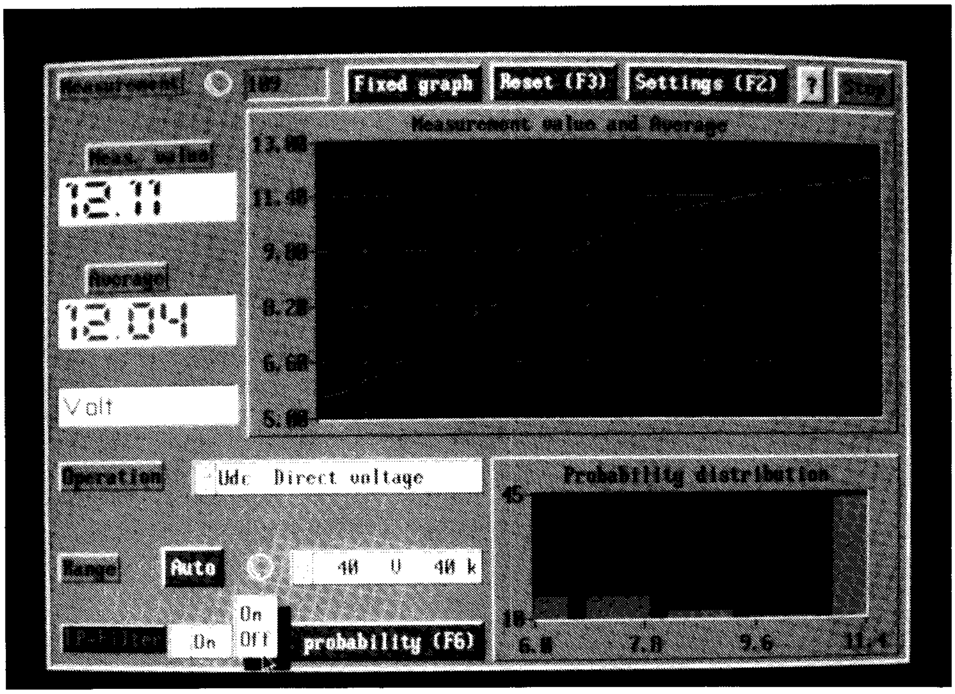


Fig. 7. The link between the PC interface and the I/O card is a bus formed by a length of flatcable. The number of connectors pressed on to the cable depends on the number of cards you wish to connect.

Software

The DMM does nothing without the appropriate software. Fortunately, this is available on a diskette for IBM PC-ATs (and up) running under MS-DOS. The control software package is called 'Fuzzy Control One', and has been produced by MicroSource. The introduction version of this program is available through our Readers Services, while the full version may be obtained from MicroSource only. As already indicated by its name, the program is tailored to developing control systems using fuzzy logic (Ref. 1). In spite of the designation 'introduction version', all features are available for use — more about this in next month's concluding instalment of this article.

For now, the part of the program that contains the multimeter software



Meas. value 12.11

Average 12.04

Volt

Operation Udc Direct voltage

Range Auto 40 U 40 k

LP-Filter On

Fig. 8. It is the DVM software contained on the Fuzzy Control One diskette that turns the combination of the DMM card and the PC into a digital multimeter with some astounding functions. Routines from LabWindows handle the graphics presentation of the measurement data, affording ease of program operation (using the mouse).

is of interest. Originally, the multimeter was intended as an aid in setting up fuzzy logic control systems. It grew, however, into a fully fledged measuring instrument.

The GUI creation routines are the only ones actually used from the 'LabWindows' package to develop the Fuzzy Control One software. Attention: LabWindows has nothing to do with MicroSoft Windows! Our thanks are due to National Instruments for allowing us to put Fuzzy Control One on floppy disk without having to raise a licence fee for every user. This means that the Fuzzy Control One software is not dearer than most other programs sold through our Readers Services.

It can not be denied that Fuzzy Control One, despite being an 'introduction version', is a very complex program, which requires quite a bit of getting used to. The range of settings and options offered by the program to implement a fuzzy logic control system is staggering, and make the program one of a kind. Documentation is not lacking, either: the total size of the help files alone would easily fill all the pages of this magazine! Incidentally, the help files can be printed, so a manual is readily produced.

A couple of batch programs containing useful examples are supplied to get you going. One of these files, DVM.BAT, launches the multimeter software. Installation is easy: simply start the INSTALL batch, and follow the instructions. After installation, the program always shows the help text when the multimeter is started. This can be turned off by quitting the multimeter and returning to the main menu. Select 'preferences'* from the 'Miscellaneous' menu. After quitting the help text on this part of the program you can turn off the option 'start with help'. To save this setting, store it in the file DVM.FZH. This is done via the 'files' and 'save hardware settings' menus.

The main menu also has an option called 'print data', which enables you to produce hard copy of the help texts (first, however, ascertain the printer port in the same menu).

After starting the multimeter program, you are eventually presented with a screen that contains the following information: current measurement value, average value measured over a predefined number of samples (both values are displayed numerically in a graph), the set measurement range, the type of measurement, the number of measurements used to compute the average ('filter length'), and a histogram that shows the variance of the measurement values contained in the filter, or in a memory containing 100 measurements. In this way, you obtain information on the measurement value proper, its trend and stability. A number of meter settings can be changed by pointing the cursor at the relevant button and clicking on it. One button determines the rate of zero measurements performed by the instrument. This is necessary to compensate the internal offset of the DMM chip. The software has to deduce the result of the zero measurement from the current measurement value to obtain the real value. Another setting made via this window is 'software calibration', which allows the scale of the DMM to be adapted without having to redo the calibration of the DMM card itself.

The 'preferences' menu also allows you to select the mains frequency (50 Hz or 60 Hz). As already discussed, the reference voltage on the DMM board depends on this frequency, and it is vital to make the selection equal to the mains frequency used in your country. If the set mains frequency is changed, the DMM card has to be calibrated again.

Calibration

Once you have familiarized yourself a little with the control software, the meter is ready for calibration. For some applications it is sufficient to set P1 to the centre of its travel. For instance, if you intend to change the calibration via software. However, if the meter is to measure 'real' volts, ampères and ohms, P1 has to be set more accurately. All you need for this purpose are a stable voltage of (nearly) 3.999 V, and an accurate voltmeter (min. 3¾ digit, and having an accuracy better than that of the DMM). Connect the test voltage to the DMM inputs, and set the meter to the 4-V range (i.e., autoranging function switched off). To prevent overflow, the input voltage has to stay just under 4 V. The adjustment of P1 is simple: turn the wiper until the DMM reads the same value as the voltmeter you have connected in parallel. That is all! All other ranges are then automatically calibrated.

Next month's instalment will discuss the Fuzzy Control One software in greater detail, along with an example of a fuzzy logic control system that makes use of the multimeter described here.

Reference:

1. Fuzzy logic: an introduction. *Elektor Electronics* July/August 1992.

Fuzzy Systems and *MikroSysteem (MicroSystem)* are registered trademarks of MicroSource/H. Scholten, P.O. Box 1243, 8001 BE Zwolle, Holland.

LabWindows a is registered trademark of National Instruments.

---

* names of menus and menu options mentioned in this article may be different from the actual names used in the program.

ESR ELECTRONIC COMPONENTS

Station Road, Cullercoats,
Tyne & Wear NE30 4PQ
Tel. 091 251 4363 Fax. 091 252 2296

DEPT. EE

74LS-Series

74LS00	£0.14
74LS01	£0.14
74LS02	£0.14
74LS03	£0.14
74LS04	£0.14
74LS05	£0.14
74LS08	£0.14
74LS09	£0.14
74LS10	£0.14
74LS107	£0.23
74LS109	£0.21
74LS11	£0.17
74LS112	£0.21
74LS113	£0.21
74LS114	£0.21
74LS12	£0.14
74LS122	£0.31
74LS123	£0.31
74LS125	£0.21
74LS126	£0.21
74LS13	£0.14
74LS132	£0.21
74LS133	£0.18
74LS136	£0.16
74LS138	£0.24
74LS139	£0.25
74LS14	£0.18
74LS145	£0.56
74LS147	£1.26
74LS148	£0.70
74LS15	£0.14
74LS151	£0.25
74LS153	£0.25
74LS154	£0.70
74LS155	£0.25
74LS156	£0.25
74LS157	£0.25
74LS158	£0.25
74LS160	£0.32
74LS161	£0.32
74LS162	£0.32
74LS163	£0.32
74LS164	£0.26
74LS165	£0.48
74LS170	£0.30
74LS173	£0.24
74LS174	£0.24
74LS175	£0.24
74LS190	£0.25
74LS191	£0.24
74LS192	£0.24
74LS193	£0.24
74LS195	£0.24
74LS196	£0.24
74LS197	£0.24
74LS20	£0.16
74LS21	£0.14
74LS22	£0.14
74LS221	£0.36
74LS240	£0.32
74LS241	£0.32
74LS242	£0.32
74LS243	£0.32
74LS244	£0.32
74LS245	£0.33
74LS247	£0.32
74LS251	£0.24
74LS257	£0.24
74LS258	£0.24
74LS26	£0.14
74LS266	£0.14
74LS27	£0.14
74LS273	£0.32
74LS279	£0.25
74LS30	£0.14
74LS32	£0.14
74LS365	£0.21
74LS367	£0.21
74LS368	£0.21
74LS37	£0.14
74LS373	£0.32
74LS374	£0.32
74LS375	£0.34
74LS377	£0.32
74LS378	£0.62
74LS38	£0.14
74LS390	£0.25
74LS393	£0.24
74LS395	£0.26
74LS399	£0.62
74LS40	£0.14
74LS42	£0.25
74LS47	£0.42
74LS51	£0.14
74LS670	£0.69
74LS73	£0.17
74LS74	£0.19
74LS75	£0.19
74LS76	£0.25
74LS83	£0.31
74LS85	£0.35
74LS86	£0.20
74LS90	£0.23
74LS92	£0.35
74LS93	£0.25

ENAMELLED COPPER WIRE

All 2oz Reels

14 SWG	£0.63
16 SWG	£0.67
18 SWG	£0.67
20 SWG	£0.72
22 SWG	£0.76
24 SWG	£0.80
26 SWG	£0.89
28 SWG	£0.91
30 SWG	£0.93
32 SWG	£0.93
34 SWG	£0.99
36 SWG	£1.04
38 SWG	£1.10
40 SWG	£1.22

4000 Series

4000	£0.17
4001	£0.17
4002	£0.17
4006	£0.32
4007	£0.17
4008	£0.31
4009	£0.19
4010	£0.23
4011	£0.16
4012	£0.16
4013	£0.17
4014	£0.30
4015	£0.31
4016	£0.18
4017	£0.27
4018	£0.27
4019	£0.19
4020	£0.31
4021	£0.31
4022	£0.32
4023	£0.16
4024	£0.21
4025	£0.15
4026	£0.59
4027	£0.18
4028	£0.22
4029	£0.27
4030	£0.17
4031	£0.70
4033	£0.56
4034	£1.24
4035	£0.31
4040	£0.29
4041	£0.31
4042	£0.22
4043	£0.28
4044	£0.35
4046	£0.31
4047	£0.25
4048	£0.31
4049	£0.20
4050	£0.20
4051	£0.25
4052	£0.25
4053	£0.25
4054	£0.56
4055	£0.34
4060	£0.31
4063	£0.29
4066	£0.18
4067	£1.91
4068	£0.16
4069	£0.20
4070	£0.17
4071	£0.20
4072	£0.17
4073	£0.17
4075	£0.17
4076	£0.30
4077	£0.17
4081	£0.14
4082	£0.17
4085	£0.28
4086	£0.26
4089	£0.55
4093	£0.18
4094	£0.31
4095	£0.56
4097	£1.20
4098	£0.31
4099	£0.38
4502	£0.38
4503	£0.31
4508	£0.90
4510	£0.26
4511	£0.32
4512	£0.32
4514	£0.73
4515	£0.98
4516	£0.31
4518	£0.27
4520	£0.26
4521	£0.62
4526	£0.40
4527	£0.39
4528	£0.40
4529	£0.44
4532	£0.32
4534	£2.24
4536	£1.00
4538	£0.37
4541	£0.33
4543	£0.46
4555	£0.34
4556	£0.34
4560	£1.18
4566	£1.96
4572	£0.25
4584	£0.24
4585	£0.32
4724	£0.70
40106	£0.31
40109	£0.50
40163	£0.46
40174	£0.34
40175	£0.36
40193	£0.60

TRANSISTORS

2N1613	£0.31	BC186	£0.33	BD534	£0.47
2N1711	£0.26	BC204C	£0.72	BD535	£0.48
2N1893	£0.29	BC206B	£0.72	BD536	£0.65
2N2218A	£0.28	BC207C	£0.72	BD646	£0.52
2N2219A	£0.25	BC208	£0.72	BD648	£0.52
2N2222A	£0.16	BC209A	£0.72	BD650	£0.53
2N2646	£0.80	BC212	£0.08	BD707	£0.42
2N2904A	£0.25	BC212L	£0.08	BD807	£0.80
2N2905A	£0.23	BC212LB	£0.08	BDX32	£1.78
2N2907	£0.20	BC213	£0.08	BDX33C	£0.46
2N2926	£0.16	BC213LC	£0.08	BDX34C	£0.50
2N3053	£0.27	BC214	£0.08	BDX53C	£0.47
2N3054	£0.90	BC214L	£0.08	BDX54C	£0.50
2N3055	£0.62	BC237B	£0.09	BF180	£0.31
2N3440	£0.50	BC238C	£0.09	BF182	£0.31
2N3702	£0.09	BC239C	£0.10	BF185	£0.31
2N3703	£0.10	BC251	£0.13	BF194	£0.19
2N3704	£0.10	BC252	£0.13	BF195	£0.19
2N3705	£0.10	BC261B	£0.24	BF244	£0.35
2N3706	£0.10	BC262B	£0.24	BF257	£0.33
2N3771	£1.44	BC267B	£0.30	BF259	£0.33
2N3772	£1.51	BC307	£0.10	BF337	£0.36
2N3773	£1.79	BC308	£0.10	BF355	£0.38
2N3819	£0.40	BC327	£0.10	BF423	£0.13
2N3820	£0.58	BC328	£0.10	BF451	£0.19
2N3904	£0.10	BC337	£0.10	BF459	£0.29
2N3905	£0.10	BC338	£0.10	BF469	£0.36
2N3906	£0.10	BC414C	£0.13	BFX29	£0.29
2N4036	£0.31	BC441	£0.40	BFX84	£0.31
2N5296	£0.57	BC461	£0.40	BFX85	£0.31
2N5321	£0.57	BC463	£0.29	BFY50	£0.29
2N6107	£0.60	BC478	£0.32	BFY51	£0.26
AC126	£0.30	BC479	£0.32	BFY52	£0.28
AC127	£0.30	BC490	£0.24	BS107	£0.21
AC128	£0.28	BC516	£0.22	BS170	£0.21
AC187	£0.45	BC517	£0.20	BSW66	£1.35
AC188	£0.37	BC527	£0.20	BU126	£1.70
ACY17	£3.84	BC528	£0.20	BU205	£1.82
AD149	£1.67	BC537	£0.20	BU208A	£1.73
AD161	£0.92	BC546C	£0.08	BU326A	£1.80
AD162	£0.92	BC547C	£0.09	BU500	£2.32
BC107	£0.14	BC548C	£0.08	BU508A	£1.76
BC107B	£0.15	BC549C	£0.10	BU526	£2.24
BC108	£0.13	BC550C	£0.08	BU806	£1.36
BC108A	£0.14	BC556A	£0.08	BUX84	£0.77
BC108C	£0.14	BC557C	£0.08	IRF540	£1.60
BC109	£0.14	BC558C	£0.08	IRF740	£1.63
BC109C	£0.15	BC559C	£0.08	MJ11015	£2.11
BC114	£0.41	BC560B	£0.09	MJ11016	£2.11
BC115	£0.41	BC637	£0.21	MJ2501	£1.60
BC116	£0.41	BC638	£0.21	MJ3001	£1.52
BC118	£0.41	BC639	£0.21	MJE340	£0.40
BC132	£0.36	BC640	£0.21	MJE350	£0.42
BC134	£0.36	BCY70	£0.21	MPSA13	£0.12
BC135	£0.36	BCY71	£0.20	MPSA42	£0.17
BC140	£0.25	BCY72	£0.20	MRF475	£6.21
BC141	£0.27	BD135	£0.20	TIP121	£0.35
BC142	£0.31	BD136	£0.21	TIP122	£0.37
BC143	£0.34	BD137	£0.22	TIP125	£0.37
BC149	£0.12	BD138	£0.22	TIP127	£0.37
BC154	£0.36	BD139	£0.23	TIP132	£0.46
BC157	£0.12	BD140	£0.24	TIP137	£0.46
BC159	£0.12	BD150C	£0.82	TIP142	£1.06
BC160	£0.28	BD165	£0.42	TIP147	£1.12
BC170	£0.16	BD166	£0.35	TIP2955	£0.63
BC170B	£0.16	BD187	£0.39	TIP29C	£0.31
BC171	£0.11	BD201	£0.40	TIP3055	£0.63
BC171B	£0.16	BD202	£0.40	TIP30C	£0.31
BC172	£0.13	BD203	£0.40	TIP31C	£0.32
BC172B	£0.13	BD204	£0.40	TIP32C	£0.32
BC177	£0.18	BD222	£0.40	TIP33C	£0.72
BC178	£0.18	BD225	£0.42	TIP41A	£0.36
BC179	£0.17	BD232	£0.38	TIP42C	£0.38
BC182	£0.08	BD237	£0.32	TIP47	£0.48
BC182L	£0.08	BD238	£0.32	TIP48	£0.62
BC182LB	£0.08	BD240B	£0.37	TIP50	£0.53
BC183	£0.08	BD243B	£0.50	VN10KM	£0.44
BC183L	£0.08	BD244A	£0.53	VN66AF	£1.50
BC183LB	£0.08	BD246	£1.06	ZTX300	£0.16
BC184	£0.08	BD441	£0.41	ZTX500	£0.16
BC184L	£0.08	BD442	£0.41		

TRIACS

Z0105DA	£0.42
TIC206D	£0.65
TIC226D	£0.73
BTA08-600B	£0.84
TIC236D	£0.96
DIAC	£0.20

VOLTAGE REGULATORS

78L05	£0.24
78L12	£0.24
78L15	£0.24
79L05	£0.28
79L12	£0.28
79L15	£0.28
7805	£0.28
7812	£0.28
7815	£0.28
7905	£0.38
7912	£0.38
7915	£0.38
LM317T	£0.44
LM723	£0.29
L200CV	£1.16
LM323K	£2.70
LM338K	£5.52

OPTO DEVICES

5mm Red LED	£0.09
5mm Green LED	£0.10
5mm Yellow LED	£0.10
5mm Orange LED	£0.10
3mm Red LED	£0.08
3mm Green LED	£0.12
3mm Yellow LED	£0.13
3mm Orange LED	£0.13
5mm Flashing Red	£0.50
5mm Flashing Green	£0.54
5mm Bi Colour	£0.36
5mm Tri Colour	£0.48
5mm Plastic Bezel	£0.04
3mm Plastic Bezel	£0.05
0.3" 7 Segment Display Red	
common anode	£1.14
common cathode	£1.14

THYRISTORS

PO102AA	£0.30
TIC106D	£0.40
TIC116D	£0.66
TIC126D	£0.77

HARDWARE

T2 Box 75 x 56 x 25mm	£0.82
T3 Box 75 x 51 x 25mm	£0.82
T4 Box 111 x 57 x 22mm	£0.98
MB1 Box 79 x 61 x 40mm	£1.44
MB2 Box 100 x 76 x 41mm	£1.56
MB3 Box 118 x 98 x 45mm	£1.82
MB5 Box 150 x 100 x 60mm	£2.50

ELECTROLYTIC RADIAL CAPACITORS

uF	16V	25V	63V	100V	450V
0.47	–	–	£0.05	£0.07	–
1.0	–	–	£0.05	£0.06	£0.15
2.2	–	–	£0.05	£0.06	£0.18
4.7	–	–	£0.05	£0.08	£0.30
10	£0.05	£0.05	£0.06	£0.08	£0.48
22	£0.05	£0.05	£0.09	–	–
47	£0.06	£0.06	£0.11	–	–
100	£0.06	£0.09	£0.11	–	–
220	£0.09	£0.12	£0.31	–	–
470	£0.15	£0.19	£0.57	–	–
1000	£0.22	£0.29	–	–	–
2200	£0.37	£0.57	–	–	–
4700	–	£1.11	–	–	–

ELECTROLYTIC AXIAL CAPACITORS

uF	16V	25V	63V	100V	450V
0.47	–	–	–	£0.15	–
1.0	–	–	£0.10	£0.10	£0.19
2.2	–	–	£0.10	£0.10	£0.22
4.7	–	£0.09	£0.10	£0.10	£0.34
10	–	£0.12	£0.12	£0.12	£0.48
22	–	£0.09	£0.13	£0.17	£1.06
47	£0.10	£0.11	£0.16	£0.20	£1.33
100	£0.10	£0.13	£0.21	–	£2.46
220	£0.13	£0.18	£0.42	–	–
470	£0.21	£0.24	£0.69	–	–
1000	£0.33	£0.40	£1.05	–	–
2200	£0.52	£0.64	–	–	–
4700	£0.90	–	–	–	–

LINEAR ICs

CA311E	£0.28
CA324	£0.23
CA555	£0.22
CA741CE	£0.18
CA747CE	£0.39
CA3046	£0.37
CA3080	£0.72
CA3130	£0.98
CA3130E	£0.98
CA3140	£0.56
CA3240	£1.22
ICL7621	£1.70
ICM7555	£0.43
ICM7556	£0.96
LM301A	£0.25
LM348N	£0.31
LF351N	£0.36
LF353	£0.41
LM358N	£0.27
LM377	£2.57
LM380N	£1.12
LM381	£2.70
LM386	£0.48
LM387	£1.60
LM392N	£0.79
LM393N	£0.28
LM748CN	£0.31
LM1458	£0.26
LM3900	£0.72
LM3914	£2.70
LM3915	£2.70
MC3340	£1.60
MC4558	£0.36
NE531	£1.56
NE556N	£0.36
NE567N	£0.36
NE5532	£0.80
NE5534	£0.66
TBA120S	£0.77
TBA810S	£0.68
TBA820M	£0.39
TDA2030	£1.35
TL061	£0.35
TL062	£0.42
TL064	£0.46
TL071CP	£0.32
TL072CP	£0.34
TL074CN	£0.48
TL081	£0.33
TL082CP	£0.34
TL084CN	£0.46
UA733	£0.64
ULN2004	£0.48
ZN414Z	£1.04
ZN425E	£4.68
ZN426E	£2.61
ZN427E	£8.82
ZN428E	£6.12
ZN435E	£5.31
ZN448E	£7.92

EPROMS & RAMS

2716	£4.46
2732	£4.84
2764-25	£3.00
27C64-25	£2.80
21728-20	£3.69
27C128-20	£3.31
27256-20	£3.15
27C256-20	£3.55
27C512	£3.69
27C010	£4.97
6116-10	£1.53
6264-10	£3.06
62256-10	£4.83
4164-15	£1.78
41256-10	£2.80
511000-8	£5.61
514256-8	£5.61

DIL SOCKETS

8 Pin	£0.07
14 Pin	£0.11
16 Pin	£0.15
18 Pin	£0.15
20 Pin	£0.16
24 Pin	£0.19
28 Pin	£0.22
40 Pin	£0.25

SOLDERING IRONS

Antex Soldering irons

M 12 Watt	£7.75
C 15Watt	£7.78
G 18Watt	£7.96
CS 17Watt	£7.88
XS 25Watt	£7.96
ST4 STAND	£2.85
35Watt Gas Iron	£11.58
Desolder Pump	£3.00
Antistatic Pump	£4.30
22SWG 0.5Kg Solder	£7.40
18SWG 0.5Kg Solder	£6.60
1mm 3 yds Solder	£0.62
Desolder Braid	£0.87

RF CONNECTORS

BNC Solder Plug 50R	£0.93
BNC Solder Plug 75R	£0.96
BNC Crimp Plug 50R	£0.68
BNC Crimp Plug 75R	£0.68
BNC Solder Skt	£1.08
BNC Chassis Skt	£0.80
PL259 5.2mm	£0.68
PL259 11mm	£0.62
RND UHF socket	£0.68
SQR UHF socket	£0.45
F Plug RG58	£0.30
F Plug RG6	£0.27
N Plug RG8	£1.60
N Socket RG8	£1.40
BNC Crimp Pliers	£15.50

PCB EQUIPMENT

UV EXPOSURE UNIT	£67.38
PLASTIC DEVELOPING TRAY	£1.35
PHOTO RESIST AEROSOL SPRAY (100ml)	£3.90
FERRIC CHLORIDE CRYSTALS (0.5Kg)	£2.45
TIN PLATING POWDER (90g)	£10.80
ETCH RESIST PEN	£0.72
PCB POLISHING BLOCK	£1.84

STRIPBOARD 0·1 PITCH

64mm x 25mm	£0.27
64mm x 95mm	£0.90
64mm x 431mm	£3.22
95mm x 127mm	£1.50
95mm x 95mm	£1.10
95mm x 431mm	£4.80
100mm x 160mm	£1.60
119mm x 454mm	£6.20

BREADBOARD

81mm x 60mm	£3.06
175mm x 42mm	£3.74
175mm x 67mm	£5.56
203mm x 75mm includes mounting plate & posts	£7.36

COPPER BOARD (G. Fibre)

100mm x 160mm	£0.90
110mm x 220mm	£1.24

PHOTO RESIST BOARD (G. Fibre)

3" x 4"	£0.86
4" x 6"	£1.62
4" x 8"	£2.09
6" x 6"	£2.41

PHOTO RESIST BOARD (Paper)

3" x 4"	£0.67
4" x 6"	£1.24
4" x 8"	£1.58
8" x 10"	£4.63

CAPACITORS

Ceramic Mini Disc 100 & 63V
1.0pF to 100nF
1pF-1nF **£0.06**, 1n2-2n7 **£0.07**,
3n3-4n7 **£ 0.12**,
10n & 12n **£0.07**
Polystyrene 160V 5% 47pF to 10nF
47p-2n2 **£0.09**, 2n7-10n **£0.12**

D CONNECTORS

	Plug	Socket
9 Pin	£0.29	£0.30
15 Pin	£0.39	£0.39
15 Pin H.D.	£0.81	£0.90
23 Pin	£0.40	£0.49
25 Pin	£0.48	£0.50
9 Way plastic cover		£0.30
15 Way plastic cover		£0.33
23 Way plastic cover		£0.36
25 Way plastic cover		£0.36

SWITCHES

3amp 250v 6.4mm ⌀ mounting

SPST Toggle	£0.58
SPDT Toggle	£0.60
SPDT CO Tog	£0.64
DPDT Toggle	£0.68
DPDT CO Toggle	£0.76
DPDT CO Toggle *(biased)*	£1.20
DPDT CO Toggle (biased 1 way)	£1.20
DPDT mini slide	£0.15
Rotary Wafer 1P-12W, 2P-6W, 3P-4W, 4P-3W	£0.78
Key Switch *SPST*	£2.70
Push to make	£0.25
Push to break	£0.28
Latching Push Sqr	£0.63
PCB Tact 6 x 6mm	£0.25

BRIDGE RECTIFIERS

W005 1.5A 50V	£0.19
WO2 1.5A 200V	£0.20
BR32 3A 200V	£0.36
BR62 6A 200V	£0.64
1004 10A 400V	£1.39

RESISTORS

0.25W 5% CF E12 Series	**£0.60**/100
0.5W 5% CF E12 Series	**£0.95**/100
0.25W 1% MF E24 Series	**£1.72**/100
POTS Log or Lin 470R – 1MO 25mm dia 0.25in shaft	£0.42
PRESETS *Enclosed Horz* or Vert 100R 1MO 0.15W	£0.15
PRESETS Skeleton Horz or Vert 100R - 1MO 0.1W	£0.11

★ PLEASE STATE VALUE REQUIRED ★

COMPUTER ACCESSORIES

Parallel Printer Lead 2m	£6.90
RS232 Lead (all pins) Male Male	£3.60
RS232 Lead (all pins) Female - Male	£3.60
Centronics 36 Way Lead Male – Male	£4.78
Gender Changers	
9 Way D Mini Female to Female	£1.81
9 Way D Mini Male to Male	£1.98
25 Way D Mini Female to Female	£2.23
25 Way D Mini Male to Male	£2.23
9 Way D Female to Female	£2.33
9 Way D Male to Male	£2.33
25 Way D Female to Female	£2.71
25 Way D Male to Male	£2.71
Adaptors	
9 Way Male to 25 Way Female	£2.33
25 Way Male to 9 Way Female	£2.33
25 Way D Male to 36 Way Centronic	£3.56
25 Way Null Modem Female – Female	£3.02
25 Way Null Modem Male to Female	£3.02
25 Way Null Modem Male to Male	£3.02
RS232 Surge Protector Male - Female	£6.12
RS232 Jumper Box Male to Female	£3.02
RS232 Tester (7 LEDs) *Male – Female*	£6.59
Data Switch Boxes	
Serial Switch box - 2 Way A/B	£9.20
Serial Switch box 3 Way A/B/C	£13.16
Serial Switch box 4 Way A/B/C/D	£15.15
Serial Switch box – Cross over	£19.69
Parallel box – 2 Way A/B	£11.84
Parallel box – 3 Way A/B/C/	£17.11
Parallel box – 4 Way A/B/C/D	£18.43
Parallel box – Cross over	£20.42

DIODES

Zener Diodes 2V7 - 33V

BZY88400Mw	£0.08
BZX85 1.3W	£0.14
1N4001	£0.06
1N4002	£0.07
1N4003	£0.07
1N4004	£0.07
1N4005	£0.07
1N4006	£0.08
1N4007	£0.08
1N5400	£0.09
1N5401	£0.09
1N5402	£0.09
1N5404	£0.11
1N5406	£0.11
1N5407	£0.14
1N5408	£0.15
1N914	£0.06
1N916	£0.06
1N4148	£0.05
BY133	£0.13
OA47	£0.28
OA90	£0.07
OA91	£0.10
OA202	£0.27
BA157	£0.10
BA158	£0.10
BA159	£0.10
1N4149	£0.06
OA200	£0.10

ORDERING INFORMATION

All prices exclude VAT.
Please add £1.25 carriage to all orders and VAT (17.5%).
No minimum order charge.
Free Computer listing with all orders over £5.00.
Please send payment with your order.
PO/Cheques made payable to
ESR Electronic Components
Access & Visa cards accepted
Offical orders from schools & colleges welcome.

CALL IN – OPEN: MON-FRI 8.30-5.00 SAT 10.00-5.00

SURVEILLANCE

PROFESSIONAL QUALITY KITS

No. 1 for Kits

Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all of our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio. Note that certain products are for Overseas use only.

UTX Ultra-miniature Room Transmitter
Smallest room transmitter kit in the word! Incredible 10mm x 20mm including mic. 3-12V operation. 500m range..........£16.45

MTX Micro-miniature Room Transmitter
Best-selling micro-miniature Room Transmitter
Just 17mm x 17mm including mic. 3-12V operation. 1000m range..........£13.45

STX High-performance Room Transmitter
Hi performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22mm including mic. 6-12V operation, 1500m range..........£15.45

VT500 High-power Room Transmitter
Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm. 9-12V operation. 3000m range..........£16.45

VXT Voice Activated Transmitter
Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range...£19.45

HVX400 Mains Powered Room Transmitter
Connects directly to 240V AC supply for long-term monitoring. Size 30mm x 35mm. 500m range..........£19.45

SCRX Subcarrier Scrambled Room Transmitter
Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range..........£22.95

SCLX Subcarrier Telephone Transmitter
Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range..........£23.95

SCDM Subcarrier Decoder Unit for SCRX
Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9-12V operation..........£22.95

ATR2 Micro Size Telephone Recording Interface
Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line..........£13.45

★★★ Specials ★★★

DLTX/DLRX Radio Control Switch
Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output, momentary or alternate, 8-way dil switches on both boards set your own unique security code. TX size 45mm x 45mm. RX size 35mm x 90mm. Both 9V operation. Range up to 200m.

Complete System (2 kits)	£50.95
Individual Transmitter DLTX	£19.95
Individual Receiver DLRX	£37.95

MBX-1 Hi-Fi Micro Broadcaster
Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your favourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle. Size 27mm x 60mm. 9V operation. 250m range..........£20.95

UTLX Ultra-miniature Telephone Transmitter
Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm! Connects to line (anywhere) and switches on and off with phone use. All conversation transmitted. Powered from line. 500m range..........£15.95

TLX700 Micro-miniature Telephone Transmitter
Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range..........£13.45

STLX High-performance Telephone Transmitter
High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. Size 22mm x 22mm. 1500m range..........£16.45

TKX900 Signalling/Tracking Transmitter
Transmits a continous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m. Size 25mm x 63mm. 9V operation..........£22.95

CD400 Pocket Bug Detector/Locator
LED and piezo bleeper pulse slowly, rate of pulse and pitch of tome increase as you approach signal. Gain control allows pinpointing of source. Size 45mm x 54mm. 9V operation..........£30.95

CD600 Professional Bug Detector/Locator
Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation..........£50.95

QTX180 Crystal Controlled Room Transmitter
Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRX180 kit (see catlogue). Size 20mm x 67mm. 9V operation. 1000m range..........£40.95

QLX180 Crystal Cointrolled Telephone Transmitter
As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range..........£40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter
As per QLX180 but draws power requirements from line. No batteries required. Size 32mm x 37mm. Range 500m..........£35.95

QRX180 Crystal Controlled FM Receiver
For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as a pre-built and aligned module ready to connect on board so no difficulty setting up. Outpt to headphones. 60mm x 75mm. 9V operation..........£60.95

A build-up service is available on all our kits if required.

UK customers please send cheques, POs or registered cash. Please add £1.50 per order for P&P. Goods despatched ASAP allowing for cheque clearance. Overseas customers send sterling bank draft and add £5.00 per order for shipment. Credit card orders welcomed on 0827 714476.

OUR LATEST CATALOGUE CONTAINING MANY MORE NEW SURVEILLANCE KITS NOW AVAILABLE. SEND TWO FIRST CLASS STAMPS OR OVERSEAS SEND TWO IRCS.

SUMA DESIGNS

DEPT. EE
THE WORKSHOPS, 95 MAIN ROAD,
BAXTERLEY. NEAR ATHERSTONE,
WARWICKSHIRE CV9 2LE
VISITORS STRICTLY BY APPOINTMENT ONLY

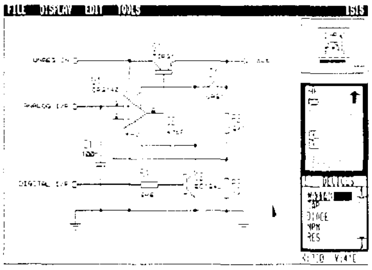
Tel: 0827 714476
Fax: 0827 714476

EASY FAST & POWERFUL

CAD SOFTWARE THAT GIVES YOU THE EDGE

ISIS - SCHEMATIC CAPTURE

Easy to use yet extremely powerful schematic entry system with all the features you need to create input for ARES or other CAD software. Now available in a super-fast 32 bit version capable of handling huge designs even on A0-sized sheets.



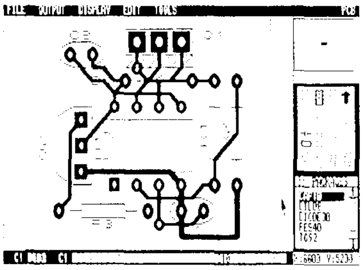
- Graphical User Interface gives *exceptional ease of use - two mouse clicks will place & route a wire.*
- Automatic wire routing, dot placement, label generation.
- 2D drawing capability with symbol library.
- Comprehensive device libraries.
- *Heterogeneous devices (e.g. relay and coil) allowed in different places on the schematic.*
- Special support for connector pins - put each pin just where you want it.
- Output to printers, plotters, Postscript.
- *Export designs to DTP and WP packages.*
- Netlist formats for most popular PCB & simulation software.
- Bill of Materials and Electrical Rules Check reports.
- Multi-sheet and hierarchical design support.
- Automatic annotation/packaging.
- ASCII data import database facility.

from

£275

ARES - PCB DESIGN

Advanced netlist based PCB layout software newly updated to version 2.5. Major new features include SMT library, real time snap (for those tricky SMT spacings), thermal relief power planes and enhanced autorouting.



- Graphical User Interface.
- *Real time snap.*
- Auto track necking.
- Curved, 45/90 or any angle tracks.
- Extensive through hole and SMT package libraries as standard.
- 2D drawing capability with symbol library.
- *Connectivity highlight.*
- Output to printers, plotters, Postscript, Gerber and NC drill.
- Gerber View facility.
- Graphics export for DTP etc.
- Advanced netlist management with forward design modification.
- *Component renumber and back-annotate to ISIS.*
- Full physical and electrical design rule checks.
- Autorouter handles single, double or multi-layer boards.
- Power plane generator with reliefs.
- *Strategy & DRC information loadable from ISIS.*
- Gerber import utility available.

from

£275

ISIS ILLUSTRATOR

Schematic capture for MS Windows 3.1 - produces high quality schematics like you see in the magazines with your choice of line thicknesses, fill styles, fonts, colours etc. Once entered, drawings can be copied to most Windows software through the clipboard.

New version 2 includes netlisting, bill of materials, hierarchy, and much more. An ideal front end for Windows Simulation and PCB design.

new low prices from

£99

CADPAK - BUDGET PRICE CAD

Two programs - ISIS SUPERSKETCH and PCB II - for the price of one.

CADPAK has everything you need to produce circuit diagrams and PCBs on your PC and is exceptionally easy to use.

superb value at only

£79

Labcenter
Electronics

*Call us today on **0274 542868** or fax **0274 481078** for a demo pack. Combination, multi-copy and educational discounts available. Prices exc P&P and VAT.*

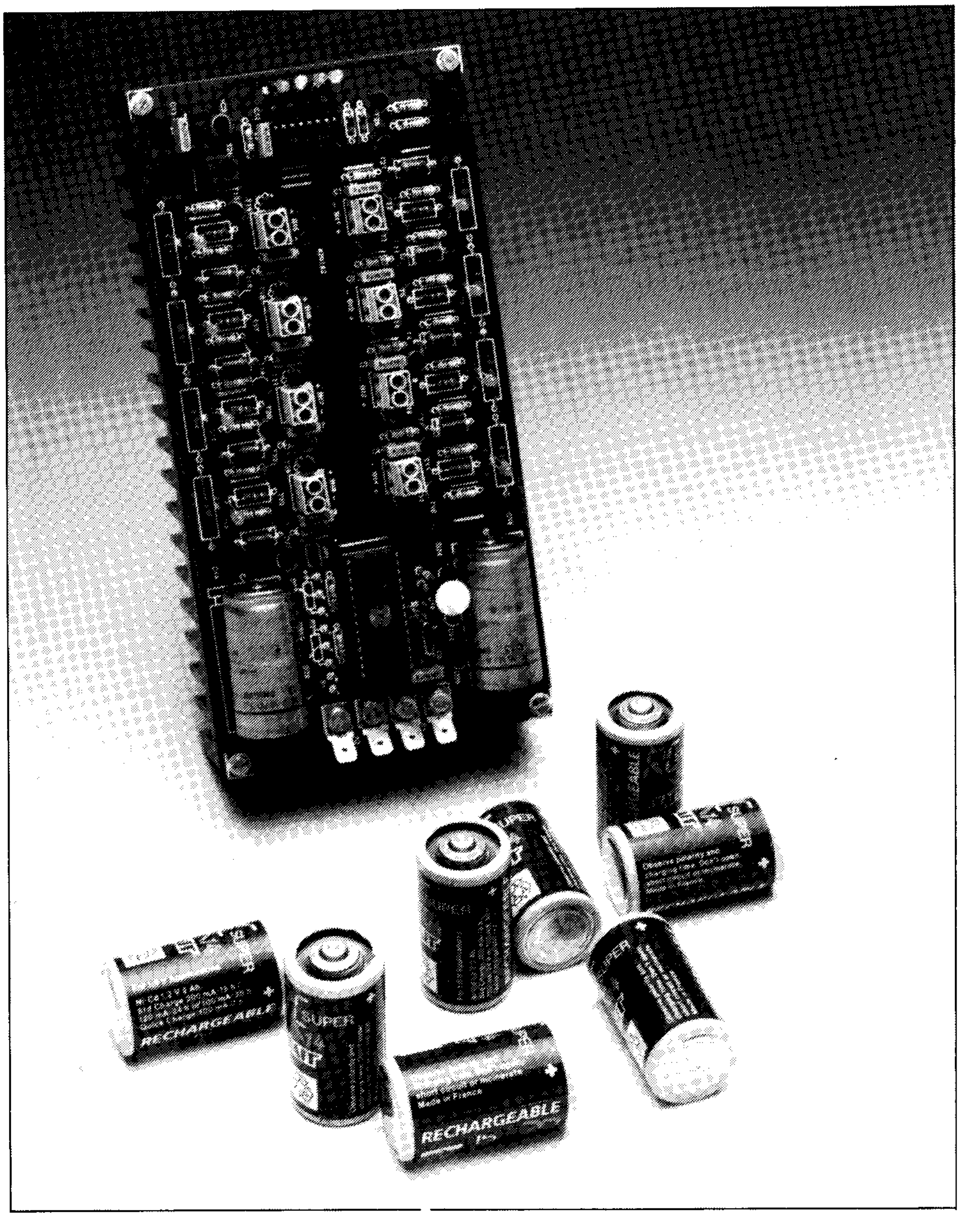
14 Marriner's Drive, Bradford, BD9 4JT.

MICROCONTROLLER-DRIVEN NiCd BATTERY CHARGER

This nickel-cadmium (NiCd) battery charger is capable of charging up to eight cells individually. The power semiconductors needed to accomplish this are all fitted on to a single, large, heatsink, to which the printed circuit board is also secured. That saves 84 wires.

Design by A. Rietjens

THERE are many methods of charging a nickel-cadmium battery. The method used by the present circuit is probably the best: first, discharge the battery, then charge it for a certain period, and, finally, trickle-charge it. Although there are more chargers that operate on this basis, you will rarely find one that offers continuous adjustment, over a wide range, of the battery capacity and the average charging current. That is a feature uniquely offered by the present charger, which enables you to charge a wide variety of batteries. It must be noted, however, that the batteries which are charged at the same time must have the same nominal capacity. Remarkably, the set charge current is achieved by applying short pulses at the maximum charging current. This ensures good efficiency of the charging process, while the combination with the discharging periods helps to counteract the so-called memory effect. In addition to controlling the charging process, the charger also has a monitoring function. The charging of a battery is stopped the moment the cell voltage rises to a too high value.



8 + 1 = 8

The block diagram of the microcontroller-driven NiCd battery charger is given in **Fig. 1**. The unit consists, broadly speaking, of eight charging circuits and a microcontroller. Each charging circuit (which is divided into a charging and a discharging circuit) handles one NiCd cell (1.2-V battery). The controller is capable of detecting whether a battery is connected or not. If so, it checks the condition of that battery via analogue inputs BT1-BT8 and an on-chip A-D converter. If a battery is detected that needs to be discharged first, the discharging function of the relevant circuit is enabled with the aid of outputs S1-S8. Any time a battery is sufficiently discharged, the associated charging circuit is switched off. When all batteries connected are discharged, the charging circuits are selected and switched to charging.

The desired charging current and the battery capacity are adjusted beforehand by two potentiometers. Like the battery voltage, the setting of these potentiometers is measured by the A-D converter on board the microcontroller. The reset button on the unit is used to signal that a set of batteries has been installed, and that the charging process must begin again.

Four LEDs indicate what the charger is doing. After a reset, the controller starts by checking all eight battery connections. In fact, it checks if a battery is present. If so, the next check is the level of discharging. During this check, the 'CHECK' LED is on. If there are batteries that need to be discharged, this is indicated by the 'DISCHARGE' LED. Another LED, marked

MAIN SPECIFICATIONS

- Charges up to eight NiCd batteries (1.2 V) simultaneously.
- If necessary, batteries are individually discharged.
- Individual monitoring of battery voltage.
- Adjustable charging current: 0-200 mA, 0-1 A, or 0-100 mA, 0-500 mA
- Adjustable capacity: 0-10 Ah or 0-5 Ah, or 0-2.5 Ah
- Trickle charging at ⅒th of nominal charging current
- Charging current indicator (LED) for each battery
- Charger state indication using 4 LEDs
- Microcontroller driven
- No adjustments

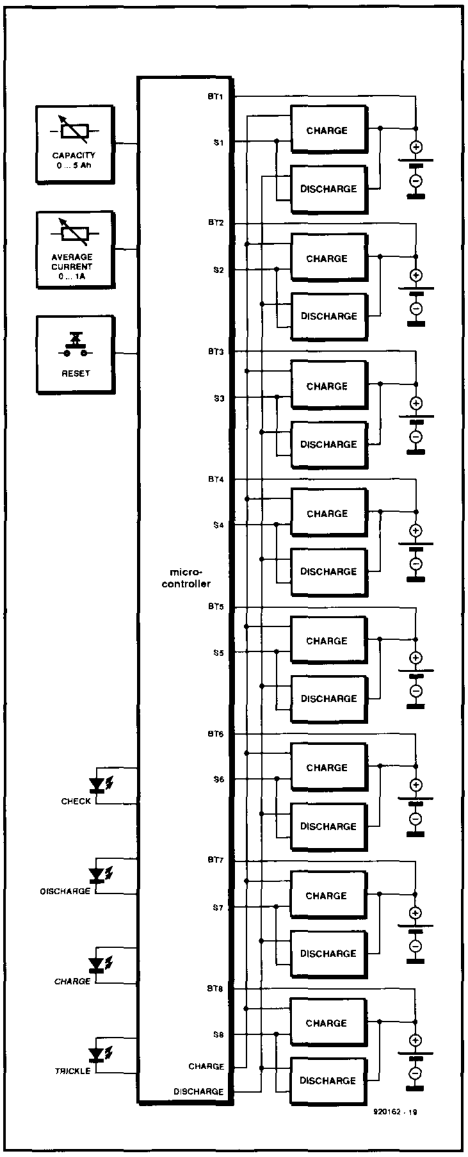


Fig. 1. Block schematic of the microcontroller-driven NiCd charger.

'CHARGE' lights when all batteries are charged. The 'TRICKLE' LED, finally, lights to indicate that the batteries are kept 'topped up' by a trickle-charging current.

Charging/discharging current and battery voltage

Neither the charging nor the discharging current flows continuously through the battery. This is because the current sources are set to fixed values. The only way of making the (average) current adjustable is, therefore, to give current pulses with an adjustable pulse duration. To generate these pulses, the microcontroller places an appropriate pulse on the 'charge' or 'discharge' control line.

Making the charging current adjustable is not the only reason to opt for current pulses: the pauses between the pulses allow the microcontroller to measure the battery voltage. This can be done without losses introduced by wires and contacts, since, theoretically, no current flows during the measurement. One complete cycle (current pulse followed by a pause during which the battery voltage is measured) lasts about 2.5 seconds.

The different steps into which the test procedure may be divided are shown in the flow diagram, **Fig. 2**. Each time the procedure is called, the voltage on all battery stations (whether 'occupied' or not) is measured. The variable 'BATCOUNT' indicates the number of the battery station (connection) whose voltage is measured. The state of each output is recorded with the aid of five variables. Three voltage ranges are set up to determine what is connected to the battery terminals. If the voltage is between 0.5 V and 1.8 V, the controller assumes that a battery is connected. If the voltage is between 0.5 V and 1 V, the battery is assumed 'flat'. Finally, if the voltage is greater than 1.6 V, it is assumed to be too high.

The results are evaluated after these three measurements. From a point of view of logic, this part of the flow diagram is not complete. Not shown are the small differences in the charging level assessment, which depend on the state of the charger (check; discharge; charge or trickle). For instance, while in 'charge' mode, it is not necessary to check if the batteries are discharged, since that has already been done. Once the state of a battery at one of the terminals has been measured, the software continues with the next one, until all have been checked. Only then does the next charging cycle begin, taking into account the result of the test routines for each individual battery.

16 current sources and one microcontroller

Before discussing the complete circuit diagram, we first examine the operation of one charging/discharging circuit — see **Fig. 3**. Transistors T25 and T28 are common to all eight charging/discharging circuits, and serve to switch between these two functions. Each circuit is individually switched on and off by the 'select' line. The bat-

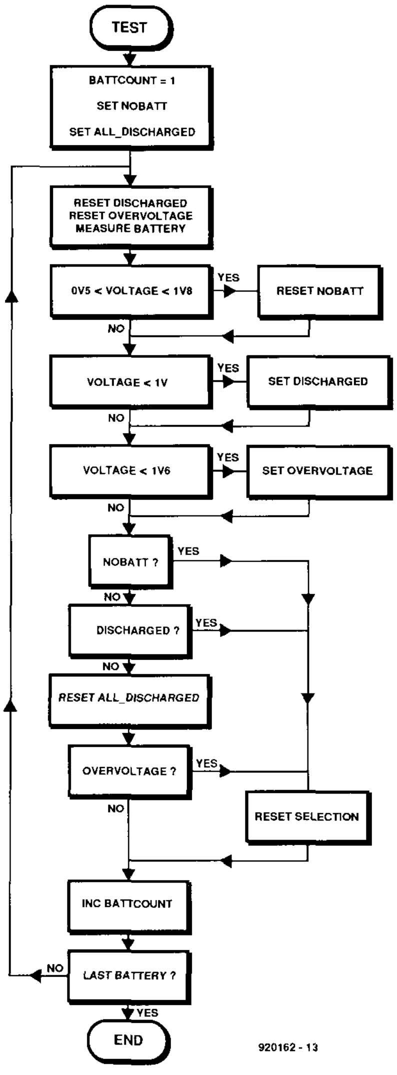


Fig. 2. The state of each battery is continuously checked during the entire charging operation.

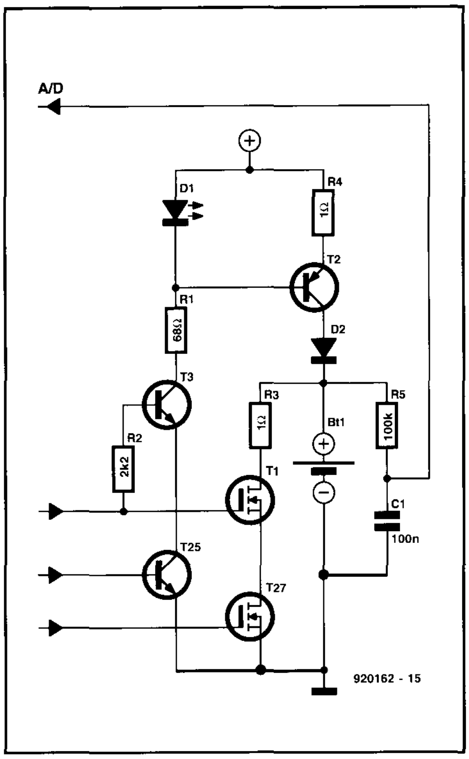


Fig. 3. Basic charging/discharging circuit. The unit has eight of these.

Table 1. Range selections

			R4;R9;R14;R19;R24;R29;R34;R39	
			1 Ω	2 Ω
Capacity	P1	JP1 open	0-5 Ah	0-2.5 Ah
Capacity	P1	JP1 closed	0-10 Ah	0-5 Ah
Charging current	P2	S1 closed	0-1 A	0-500 mA
Charging current	P2	S1 open	0-200 mA	0-100 mA

tery voltage is measured by the microcontroller via filter R5-C1. To discharge the battery, the 'select' and 'discharge' lines have to be high simultaneously. The discharging current then flows via resistor R3 (which limits the current to about 1 A), and MOSFETs T1 and T27.

If the 'select' and 'charge' lines are high, current source D1-T2-R4 is switched on, and current is supplied to the battery. LED D1 has two functions. Firstly, the voltage across it is the reference for current source T2. Secondly, it serves as a 'charge' indicator because it flashes when the relevant battery is being charged. D1 is a red LED, which has a typical voltage drop of 1.6 V. After subtracting the base-emitter voltage of T2, this leaves 1 V across R4, so that a current of 1 A flows. This constant current leaves the circuit via the collector of T2, and is fed to the battery. Diode D2 protects T2 against excessive voltages. Since D1 is used as a reference, it **must** be a red LED (the voltage across LEDs depends on the colour). Also, do not use a high-efficiency type in position D1, since that, too, causes an incorrect reference voltage.

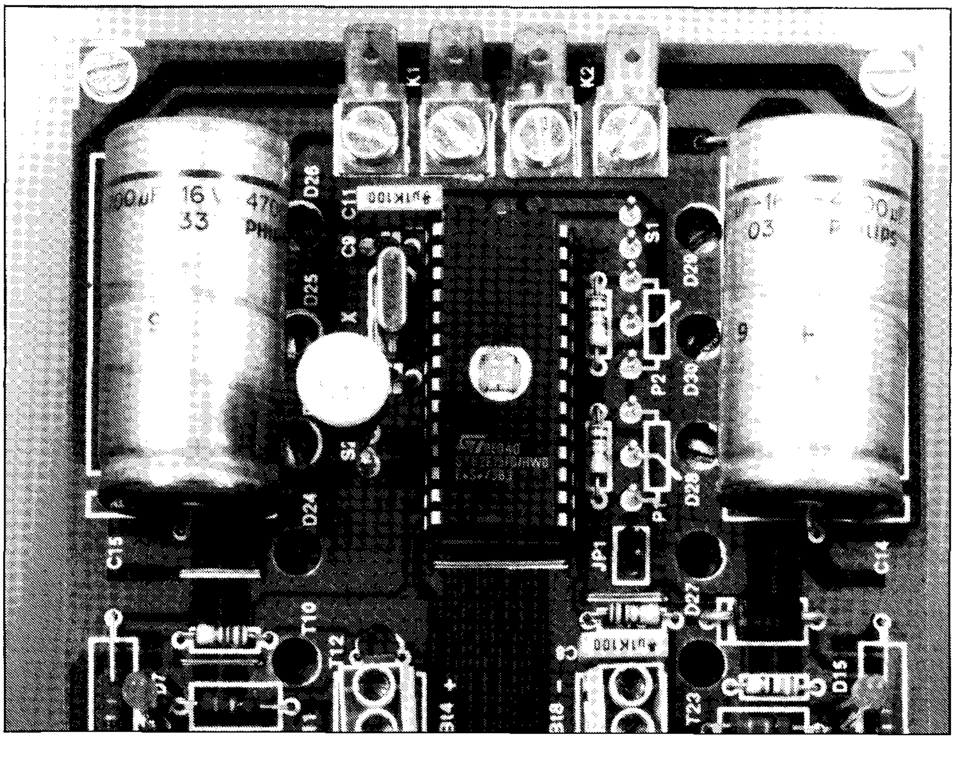
As already mentioned, the battery is charged with a current pulse every 2.5 seconds, which is indicated by the LED flashing at the same rate. If the LED does not flash, or flashes irregularly, there is probably something wrong with the relevant battery. Do note confuse irregular flashing with 'slow' flashing (every 50 s), which indicates trickle charging.

The full circuit diagram of the microcontroller-driven NiCd charger is given in **Fig. 4**. Controller IC1 is a member from the ST62xx family which was introduced in Ref. 1. The eight charging circuit are divided into two groups of four, which are separately powered. In this way, the maximum load on the charging/discharging circuits is limited to 4 A, which is easier to handle than the 8 A which would be required if all circuits were connected to a single supply.

The division into two groups is also found back with T27. To prevent all discharge currents flowing through this transistor, it is shunted by a second power MOSFET, T26. Each of these transistors handles one group of charging/discharging circuits, and, thus, half the total discharging current. Furthermore, the division into two groups comes in handy for the design of the printed circuit board, because it allows the tracks that carry the total charging/discharging current to be kept as short as possible. Transistor T25 does not need 'assistance' since it can easily handle the current drawn by the eight LEDs in the charging circuits on its own.

Since microcontroller IC1 has a limited number of inputs and outputs, the four modes of the charger (check; discharge; charge; and trickle) are conveyed to the circuit via two outputs only. These two control bits are decoded by demultiplexers IC2a and IC2b. The latter controls LEDs D19 (check), D20 (discharge), D21 (charge) and D22 (trickle). These LEDs indicate the state of the charger. IC2b decodes the two output bits to control T25, T26 and T27. In 'check' mode, these three transistors are switched off, allowing the microcontroller to measure the battery voltage (remember, no current flows at this stage). In 'discharge' mode, T26 and T27 are switched on, while T25 is switched on in 'charge' as well as in 'trickle' mode. Current pulsing is achieved by switching between 'check' mode on the one hand, and 'discharge', 'charge' or 'trickle', on the other.

The charger is adjusted with the aid of P1 and P2 (for the ranges, see Table 1). P1 enables the battery capacity, or, more properly, the energy (in Ah) put into the battery, to be set. This means that the battery charger does not compensate the efficiency of the charging process. Fortunately, that is not a problem because the efficiency of the charging process is relatively high



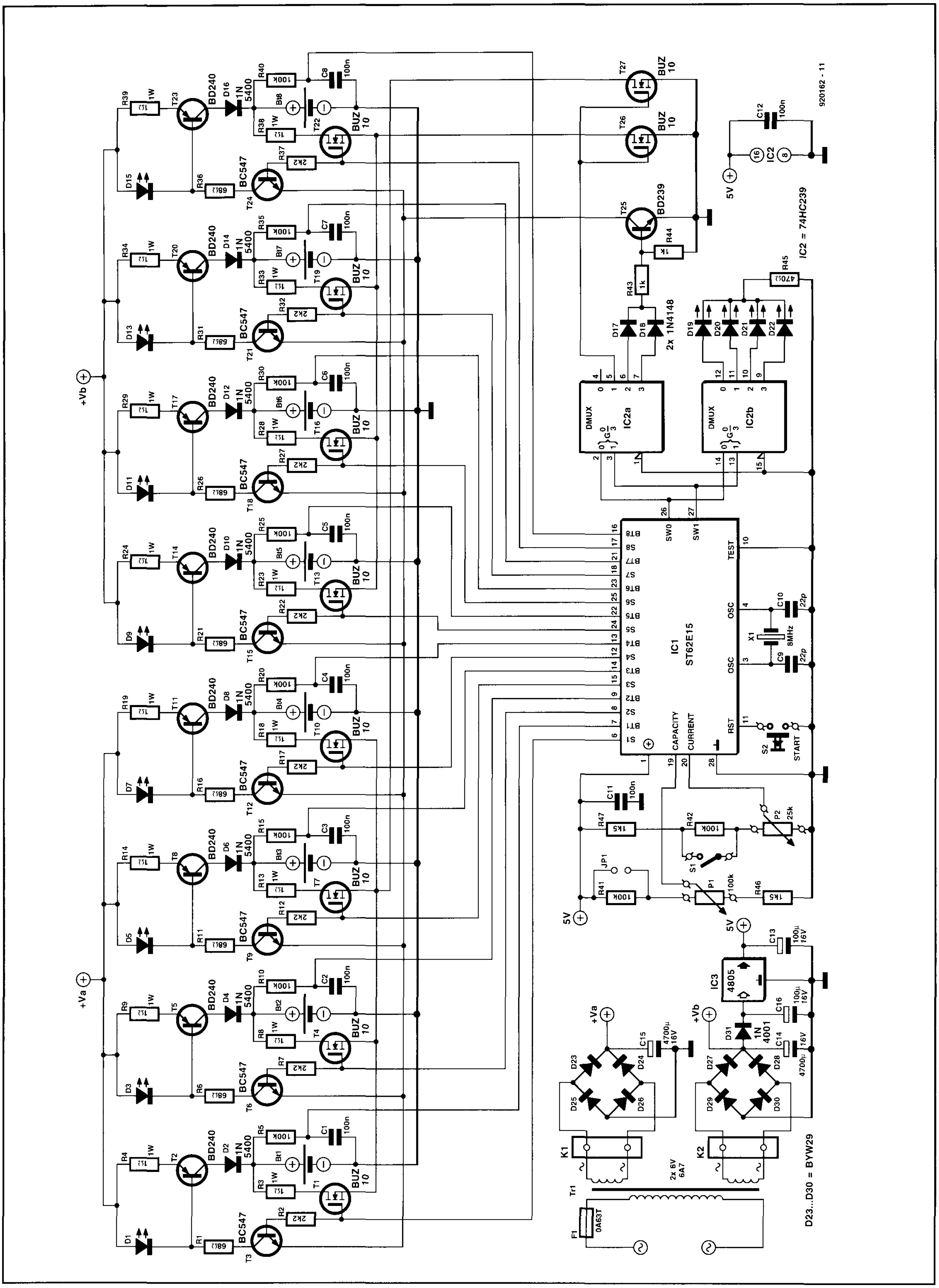


Fig. 4. Circuit diagram of the NiCd charger. Most discrete electronics is contained in the charging/discharging circuits. Inside IC1 lurks a complete computer system with RAM, ROM and an A-D converter.

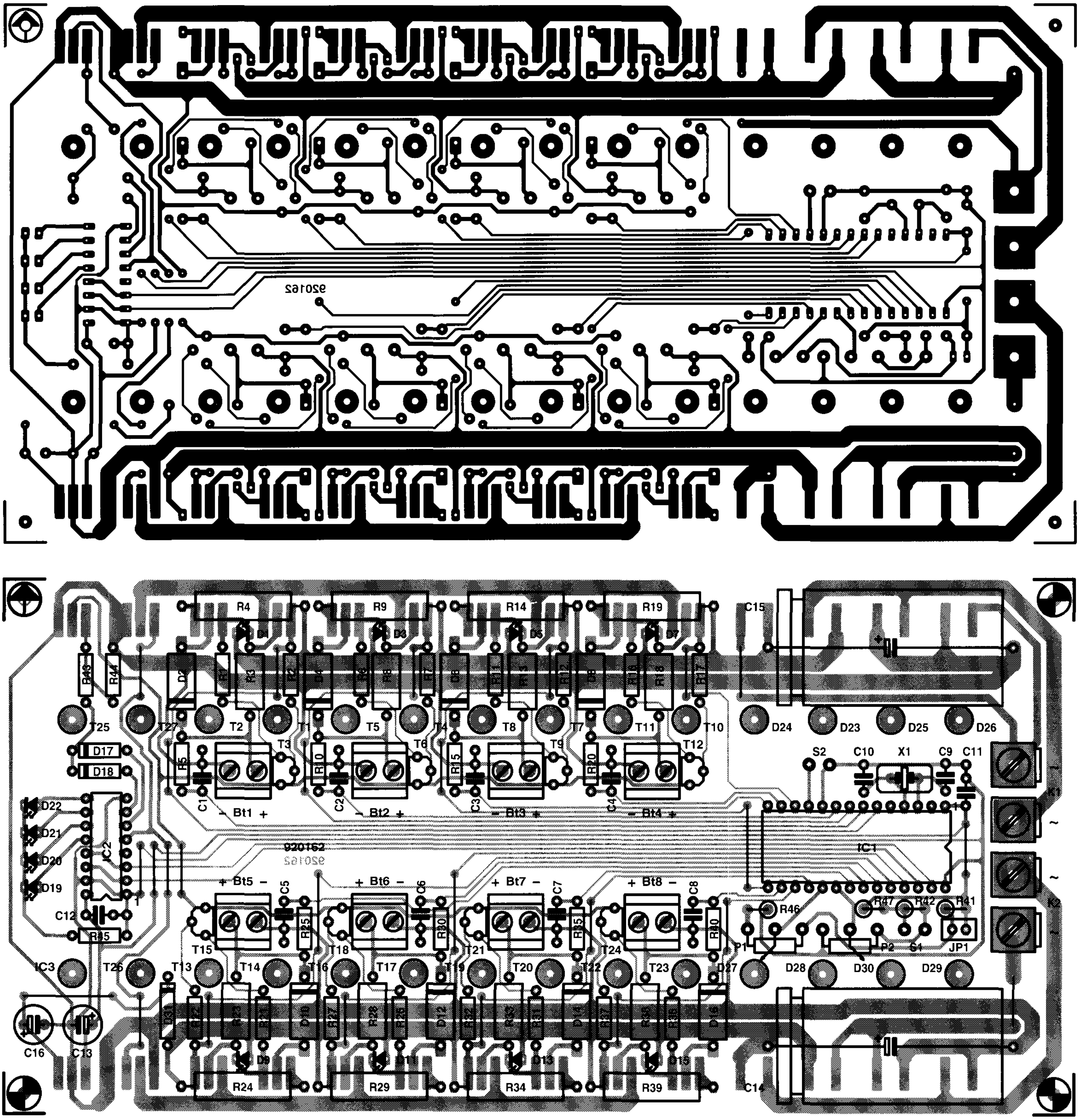


Fig. 5. The printed circuit board is designed to fit on the SK47/100/SA heatsink. Use a photocopy of the component mounting plan as a templatye to drill the holes for the power semiconductors.

by virtue of the high charging current. In practice, you will come very close to a 'full' battery if you set its nominal capacity with P1. If, after having used the batteries, they appear not to have had the full capacity, try setting a higher capacity with P1 next time (however, *do not go higher than 1.4 times the* nominal capacity).

The second control, P2, allows the average charging current to be set. That may appear strange, since the current sources pump fixed 1-A pulses through the battery, no matter how small this is. However, by matching the average current to the specification of the battery, this is given sufficient time to recover from the current pulse. Current pulses cause gas bubbles in the battery. Although these disappear as a result of the chemical reaction set off the charging current, this takes some time. Since the gas bubbles increase the pressure inside the battery, the amount of gas must be restricted. Here, this is achieved by a pause following each current pulse.

If you frequently use small batteries which seem to have problems with the 1-A charging current, it is recommended to change R4 (and its counterparts in the other current sources) from 1 Ω into 2 Ω. This modification

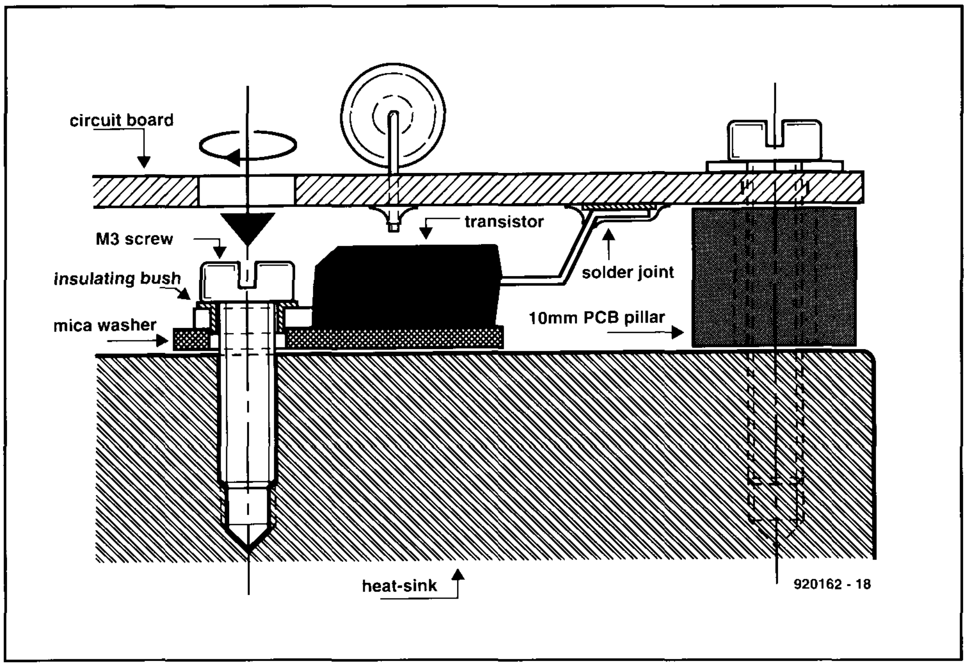
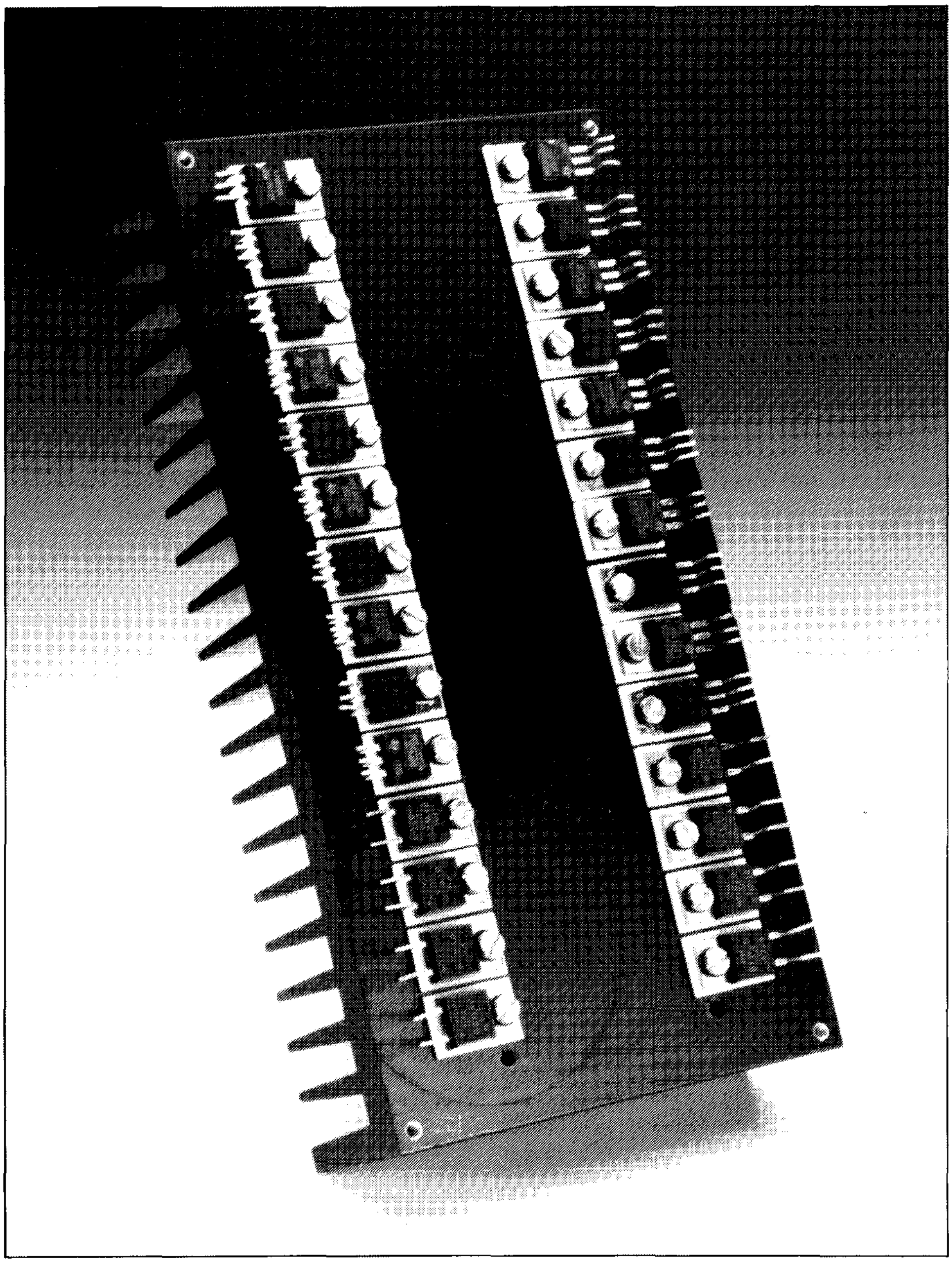


Fig. 6. Illustrating the 'sandwich' construction, with the power semiconductors fitted between the PCB and the heat-sink.



it is essential. The fuseholder holds fuse F1.

The biggest problem in the finishing of the unit is probably the battery holder. Although holders are available for single cells, these are usually suitable for internal or recessed mounting only. In any case, a multi-battery holder as seen in commercially available chargers proved impossible to find as a separate part from electronics retailers. It may, therefore, be a good idea to salvage such a holder from an inexpensive ('no-good-anyway') battery charger. Alternatively, join a couple of single-cell holders, and connect them to the charger via a short cable fitted with a plug. Another alternative, although quite costly, is to use Varta's stackable battery holders (Types RSH4 for 'mono' cells; RSH1,8 for 'baby' cells; and 501RS for 'penlights'). Whatever solution is found to solve the battery holder problem, be sure to keep the wire connections as short as possible, since the ability of the current sources to compensate losses caused by junction resistances.

Finally, scales are readily made for the two potentiometers, since their ranges are linear.

Operation

In general, use the nominal capacity of the battery to set the capacity on the NiCd charger. In virtually all cases, that is sufficient to fully charge the battery. The same goes, basically, for the charging current, which is set in accordance with the battery manufacturer's recommendations. Remember, however, that low temperatures forbid high charging currents. The charging current is too high if the battery temperature runs up to 40 °C at room temperature.

Since the capacity and charging current settings are common to all batteries connected, only batteries with equal nominal capacities can be charged at the same time. If you happen to have a number of batteries with different conditions (charging levels), remember that the charger does not start charging until the last battery is discharged. So, if you are in a hurry, it may be more economical to first charge the most discharged batteries. ■

References:

1. Maxi micro clock. *Elektor Electronics* July/August 1993.

COMPONENTS LIST

Resistors:		
8	68Ω	R1;R6;R11; R16;R21;R26; R31;R36
8	2kΩ2	R2;R7;R12; R17;R22;R27; R32;R37
16	1Ω 1W	R3;R4;R8;R9; R13;R14;R18; R19;R23;R24; R28;R29;R33; R34;R38;R39
10	100kΩ	R5;R10;R15; R20;R25;R30; R35;R40;R41; R42
2	1kΩ	R43;R44
1	470Ω	R45
2	1kΩ5	R46;R47
1	100kΩ linear potentiometer	P1
1	25kΩ linear potentiometer	P2
Capacitors:		
10	100nF	C1-C8;C11;C12
2	22pF	C9;C10
2	4700µF 16V	C14;C15
2	100µF 16V radial	C13;C16
Semiconductors:		
10	LED, red, 3mm	D1;D3;D5;D7; D9;D11;D13; D15;D19;D21
8	1N5400	D2;D4;D6;D8; D10;D12;D14; D16
2	1N4148	D17;D18
1	LED, yellow, 3mm	D20
1	LED, green, 3mm	D22
8	BYW29	D23-D30
1	1N4001	D31
10	BUZ10	T1;T4;T7;T10; T13;T16;T19; T22;T26;T27
8	BD240	T2;T5;T8;T11; T14;T17;T20; T23
8	BC547B	T3;T6;T9;T12; T15;T18;T21; T24
1	BD239	T25
1	ST62E15 microcrontroller; supplied ready-programmed; order code: 7071* (see page 70)	IC1
1	74HC239	IC2
1	4805	IC3
Miscellaneous:		
8	2-way PCB terminal block, pitch 5mm	Bt1-Bt8
1	fuse 630mA, slow	F1
1	jumper	JP1
4	PCB mount spade terminal	K1;K2
1	SPST switch	S1
1	Press-key	S2
1	Mains transformer 2x6V/6-7A	Tr1
1	8MHz quartz crystal	X1
1	Mains socket with integral fuseholder and switch	
1	Heat-sink SK47/100/SA (Fischer); size: 200x100x40mm	
1	Printed circuit board plus IC1; set order code 920162.	

* part of set 920162.

results in current pulses of 500 mA instead of 1 A (see also Table 1).

Since the energy to be put into the battery is set with the aid of P1, the charging time of the battery is easily computed by dividing the set capacity by the set current. Only if the charging current is at or near the maximum, you will have to allow for some extra time, which goes on account of the microcontroller running state checks on the batteries.

Last but not least, the power supply of the NiCd charger. The mains transformer is a fairly heavy type with two separate 6-V secondary windings, each rated at 6-7 A. Here, too, the supply is divided into two parts to keep the maximum currents within reason. None the less, the rectifier diodes have a pretty hard time, and to keep them cool they have to be fitted on the heatsink, together with the power transistors. That is also why TO-220 style diodes are used. For the rest, the power supply is straightforward: bridge rectifier, smoothing capacitor and a 5-V regulator, IC3, to supply IC1 and IC2. A low-drop voltage regulator is used because of the relatively low transformer secondary voltage (which is necessary to keep the dissipation in the current sources within limits).

Construction

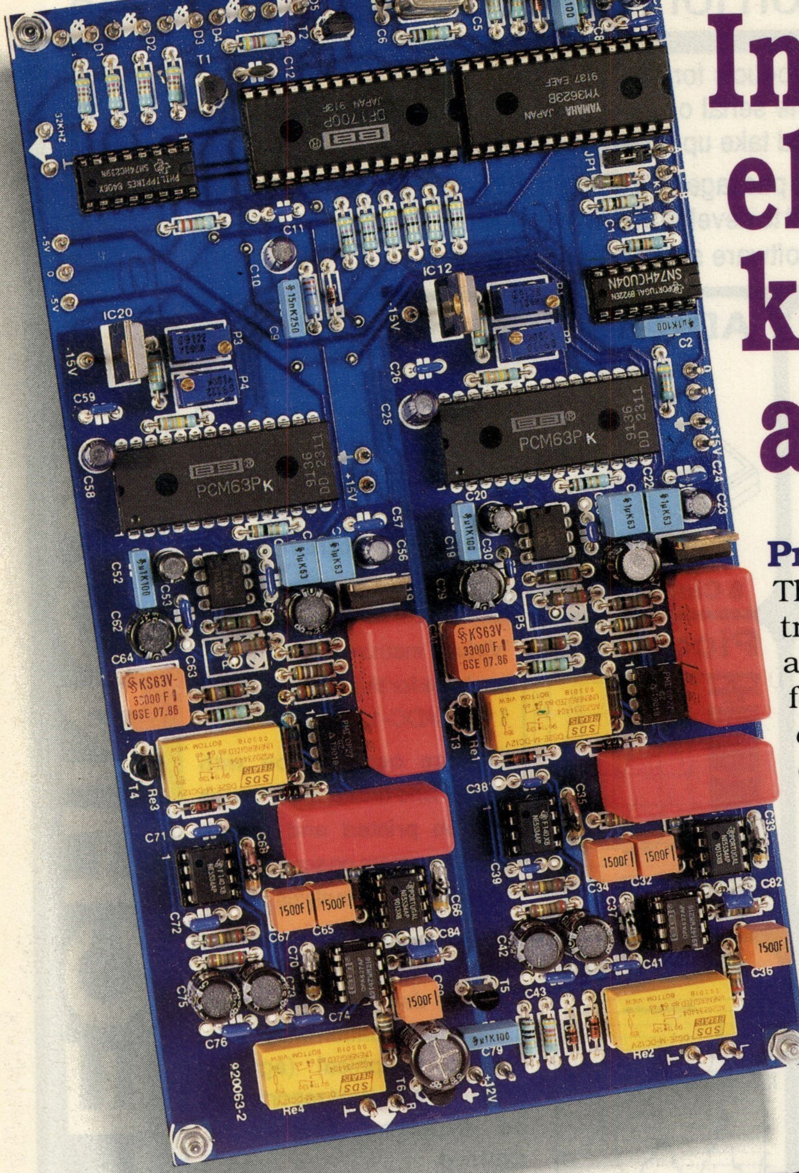
The artwork for the printed circuit board is shown in **Fig. 5**. The PCB is designed so that it forms a sandwich construction with the heat-sink. The power semiconductors are fitted between the board and the heat-sink. First, however, mount all components shown on the PCB overlay (which excludes the TO-220 style power transistors and diodes). It Is best to start with the 26 wire links on the board. Use fairly thick wire for the links next to K2 and at the head of C15, since these wires carry the full supply current. At the track side of the board, fit a 10-kΩ resistor between pin 1 (+5 V) and pin 5 (NMI) of IC1. Although this pull-up resistor should not be required, some of our prototypes of the charger did not work properly without it. Finally, check the populated PCB for errors, since these are not so easy to correct later.

To enable the sandwich construction to be made, the heat-sink has to be drilled and tapped first. Punch holes into the heatsink, using a photocopy of the component overlay to find the locations (check that your photocopier produces a copy of exactly 100%). All in all, there are 32 holes: four fixing holes, and 28 for the power transistors, diodes and IC3. Drill 2.5mm dia, 15 mm deep, holes. Deburr the holes, because the components have to rest flat on the heat-sink for optimum heat transfer. Next, thread the holes with an M3 tap. The depth of the threading is about 10 mm.

Figure 6 shows the position of the power components between the heat-sink and the PCB. Start by bending the component terminals into the shape shown. Next, mount each component on to the heat-sink, using a 10-mm bolt, insulating material and heat transfer paste. Make sure that each component is fitted the right way around, and at the right location. Next, run a check on short-circuits between the metal tabs and the heat-sink. Place the PCB over the components, so that the terminals rest against the respective copper spots. If necessary, align the components, and tighten the bolts (which are accessible through holes in the PCB). Next, solder the terminals from the side.

Connect the mains transformer, and apply power. LED D19 should light immediately. For a further check on the circuit, you need a nearly exhausted battery. Set the nominal capacity of this battery with P1, and an appropriate charging current with P2. Connect the battery to one of the PCB terminal blocks. On starting the charger by pressing S2, the CHECK LED (D19) should light briefly, followed by the DISCHARGE LED (D20) — provided, of course, that the battery is not completely discharged. If the battery is ‘flat’, the ‘CHARGE’ LED lights, and also the LED in the charging circuit to which the battery is connected. Next, all you can do is wait and see if the charger keeps to the charging time that belongs with the setting (capacity/charging current) made with P1 and P2. Since there are no adjustment points in the circuit, it is best to leave it working for a while.

Once the unit works properly, it may be finished mechanically. Great attention should be given to safety precautions for all wires and terminals that carry the mains voltage. In this respect, it is best to use a mains socket with a built-in switch and fuseholder. Note that the switch is not drawn in the circuit diagram, although



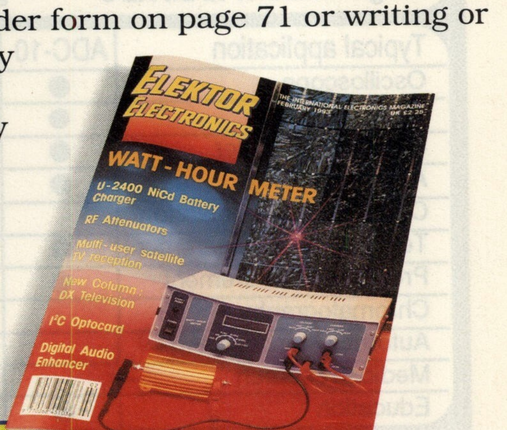
Increase your electronics know-how and skills

Practical creativity in electronics

The speed and intensity with which electronics penetrates our daily lives at home, at work, or in our car, tends to make us forget that we *can use electronics creatively* by building designs with a practical application and having the satisfaction of a successfully finished project. *Elektor Electronics*, which is distributed all over the world, can help you achieve these goals. Throughout the year, the magazine features original construction projects, informative articles and news on the gamut of electronics, science & technology, book reviews and information on new products.

The value of an annual subscription

If *you* wish to increase your electronics know-how and skills, take out an annual subscription to *Elektor Electronics* by filling in the order form on page 71 or writing or telephoning to the address below. You will then not only have the convenience of having the magazine delivered to your home and the peace of mind that you will not miss any issue, but you will also save money compared with buying the magazine from a bookstall: the price of a subscription in Britain for the 11 annually published issues is the same as the average price of 10 issues bought from a bookstall. Rates are shown on page 72.


ELEKTOR ELECTRONICS
WATT-HOUR METER
U-2400 NiCd Battery Charger
RF Attenuators
Multi-user Satellite TV reception
New Column: DX Television
I²C Optocard
Digital Audio Enhancer

World Wide Subscription Service Ltd,
Unit 4, Gibbs Reed Farm,
Pashley Road, TICEHURST,
East Sussex TN5 7HE, England
Telephone (0580) 200 657 (*National*)
or +44 580 200 657 (*International*)
Fax (0580) 200 616 (*National*)
or +44 580 200 616 (*International*)

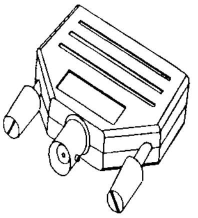
ELEKTOR
ELECTRONICS

Low cost data acquisition for IBM PCs & compatibles...

A unique range of low cost data acquisition products for IBM PCs and compatibles. Installed in seconds they simply plug directly into either the serial or parallel port. They are completely self contained, require no external power supply and take up no expansion slots.

Each device comes with an easy to use software package (PicoScope, PicoLog or both). C, Pascal, and Basic drivers are supplied for those who want to develop their own software, as is a manual giving full details of the hardware and software. All software supplied on 3.5" disk.

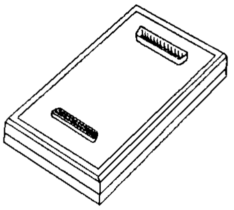
ADC-10



- Up to 24kHz sampling rate from a 386/33MHz machine
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection
- Includes PicoScope software

Single Channel 8 bit ADC £49

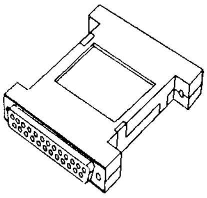
ADC-16



- Software selectable single ended or differential inputs
- Resolution programmable between 8 and 16 bits + sign
- ±2.5V input range
- 5V reference output
- Connects to serial port
- Includes PicoLog software

8 Channel 16 bit + sign ADC £99

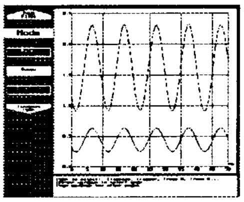
ADC-11



- 15K samples per second
- 0-2.5V Input range
- Digital output
- D25 input connector
- 30V overload protection
- Parallel port connection
- Includes both PicoScope and PicoLog software

11 Channel 10 bit ADC £75

PicoScope

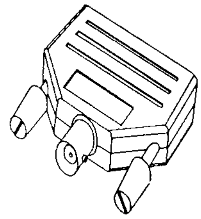


Scope, voltmeter, spectrum analyser

'Virtual instrument' software package for the ADC-10, ADC-11 and ADC-12.

Storage oscilloscope with trigger and timebase. Traces can be printed and saved. Multiple meters on screen. Real time spectrum analysis.

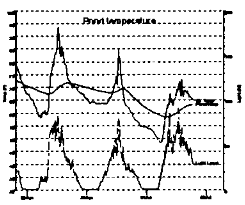
ADC-12



- Up to 18kHz sampling rate
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection
- Includes both PicoScope and PicoLog software

Single Channel 12 bit ADC £85

PicoLog



Advanced data logging software

Collect samples from 1 per ms to one per day. Scale samples linearly, by equation or by table look-up. Graphical (against time or XY) and text reports can be displayed, printed or exported.

Picolog is also available for the ADC-10 : call for details.

Typical application	ADC-10	ADC-11	ADC-12	ADC-16
Oscilloscope	●	●	●	
Voltmeter	●	●	●	●
Spectrum analyser	●	●	●	
Audio sampling	●		●	
Chart recorder emulation		●		●
Temperature measurement	●	●	●	●
Pressure measurement	●	●	●	●
Chromatography				●
Automotive monitoring		●		●
Medical research		●	●	●
Education	●	●	●	●

PICO BENEFITS

- 30 day no quibble money back policy
- Full 1 year guarantee
- 1 year's free software upgrades
- Free technical support
- Free user newsletter
- Same day dispatch

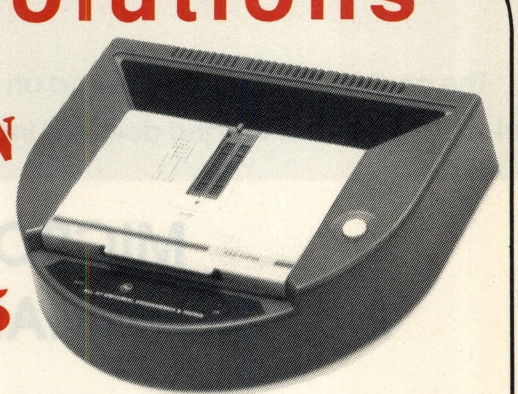
PICOTECHNOLOGY

Pico Technology Ltd. Broadway House, 149 -151 St Neots Road, Hardwick, Cambridge. CB3 7QJ.

TEL: 0954-211716 FAX: 0954-211880

Phone or FAX for sales, ordering information, data sheets, technical support. All prices exclusive of VAT.

Programming Solutions



NEW

Universal Programmer

- ✓ Built-in power supply
- ✓ Uses standard pc printer port works with notebook and handbook pc's
- ✓ PIN-driver expansion can drive up to 256 pins
- ✓ Supports over 1500 ICs:- EPROMs, E^2PROMs, Bipolars, Flash, Serial PROMs Over 150 Microcontrollers - including PIC17C42 PLDs, EPLDs, PEELs, PALs, GALs,FPGAs including MACH MAX and MAPL parts
- ✓ Powerful full colour menu driven software
- ✓ Regular updates

only **£595**

EPROM Programmer

- ✓ EPROMs E^2PROMs Flash EPROMs 8748/8751 micros
- ✓ Fast programming algorithms
- ✓ Simple colour menu operation

only **£139**

Multi Device Programmer

- ✓ EPROMs, E^2PROMs, Flash EPROMs,
- ✓ Serial PROMs, PLDs,GALs
- ✓ Intel, Microchip & Zilog Microcontrollers
- ✓ Fast programming algorithms
- ✓ Connects direct to pc printer port
- ✓ Simple full colour menu software

only **£325**

Standalone Programmers, PC based Programmers, Gang Programmers

A full range of cost effective programmers - supporting all the very latest devices

2 Field End, Arkley, Barnet, Herts EN5 3EZ Telephone: 081-441 3890
Fax: 081-441 1843

SMART COMMUNICATIONS

MACRO CROSS ASSEMBLERS
for 8051, 6800, 6809, Z80, 6502, ...
with linker and library manager £70

Demonstration
Disc £5.00

B. A. Jones
Freepost (GR1863)
Cheltenham
GLOS. GL50 3BR

Features:-
Conditional assembly,
File inclusion,
Repeated blocks,
Binary/Hex output,
Map files,
Full expression evaluation,
and much more.

IF AN ADVERT IS WRONG, WHO PUTS IT RIGHT?

We do. The Advertising Standards Authority ensures advertisements meet with the strict Code of Advertising Practice.

So if you question an advertiser, they have to answer to us.

To find out more about the ASA, please write to
Advertising Standards Authority,
Department X, Brook House,
Torrington Place, London WC1E 7HN.

ASA

This space is donated in the interests of high standards in advertisements.

Baylin Publications

ALL ITEMS EX-STOCK.

24 River Gardens,
Purley, Reading.
RG8 8BX. England.
Tel/Fax 0734-414468
Mobile 0836-582785
Pay by: UK£ cheque, Access, Mastercard, Visa, C.O.D.

Ku Band Satellite TV, Theory, Installation & Repair 4th Edition. Footprints, dish theory, cables, site survey, polar mount adjustment. ***£25.***

European Scrambling Systems, Circuits, Tactics & Techniques. By John McCormac, digital sound, smart cards, pirate decoders, for hackers. ***£32.***

World Satellite TV & Scrambling Methods. 2nd Edition, by Baylin, Madox & McCormac for the service engineer. ***£29.***

Home Satellite TV Installation Videotape. Forty minutes VHS Pal. See how 3 metre dishes are installed. ***£27.***

Satellite Installation Guide. 3rd Edition. By John Breeds. ***£13.***

The Satellite Book. 2nd Edition. A complete guide to satellite TV . Theory and practice by John Breeds. ***£31.***

World Satellite Almanac. 3rd Edition by Mark Long. 300 Footprints, Frequencies, Transponder Loading, Orbital Assignments.	***£69.***
World Satellite Annual. Update by Mark Long.	***£39.***
TVRO System Analysis and Aiming Software. 5.25 or 3.5 disk, (DOS 3.2). Calculates dish size and lists coordinates of all satellites in view.	***£39.***
Satellite Toolbox Software, for IBM Comp. Hard Disk– 5.25 or 3.5.	***£59.***
Wireless, Cable & SMATV, Microwave broadcasting & cable TV.	***£35.***
World Satellite Yearly by Dr. Baylin, Loading and 200 Footprints.	***£38.***

PRICES INCLUDE P. & P. UK. Airmail Europe add 10%. Outside Europe +20%.

APPLICATION NOTE

The content of this note is based on information received from manufacturers in the electrical and electronics industries and does not imply practical experience by *Elektor Electronics* or its consultants.

MICRO LINEAR 2035 & 2036 PROGRAMMABLE SINE WAVE GENERATORS

The ML2035 and ML2036 are monolithic sine wave generators that are programmable from d.c. to 25 kHz and from d.c. to 50 kHz respectively. The frequency can be set in steps of 0.5 Hz. They are intended primarily for telecommunications and modem applications that need low-cost and accurate generation of precise test tones, call progress tones, and signalling tones.

The frequency of the sine wave output is derived either from an external crystal or clock input, thus providing a stable and accurate frequency reference. The frequency is programmed by a 16-bit serial data word.

The ML2035 is housed in an 8-pin d.i.p. and the ML2036 in a 14-bit d.i.p. or a 16-pin SO (small outline) case.

Figure 1 shows the block diagrams of the two devices. Both contain a 16-bit shift register and associated 16-bit data latch. The content of the register determines the output frequency via a phase accumulator and 512 point sine look-up table, which will be reverted to shortly. An 8-bit digital-to-analogue (D/A) converter transforms the output of the phase accumulator into an analogue voltage that is smoothed by a filter. Furthermore, both devices have the facility for a power-down mode, which allows the digital section to be switched off. To that end, the shift register must be loaded with zeros and the LATI input connected to +5 V. The ML2036 has the further facility of an INH(ibit) function, which switches off the output when the next zero crossing of the sine wave is reached.

Whereas the ML2035 has a fixed output level of $\pm 2.5\ V_{pp}$, that of the ML2036 can be preset by the combination of the reference voltage and the logic state at the GAIN terminal. If, for instance, the GAIN pin is at +5 V (logic high), the peak output voltage is equal to the reference voltage ($V_{o(pp)} = 2V_{ref}$). If the GAIN pin is at 0 V (logic low), the peak output voltage is equal to $V_{ref} / 2$, so that $V_{o(pp)} = V_{ref}$.

The ML2036 also has two additional clock outputs, fCLKIN / 2 and fCLKIN / 8, a power-down input and isolated grounds for its analogue and digital sections.

The power requirement for both chips is ±5 V; the negative voltage is needed for the analogue section.

The digital inputs of both devices are TTL/CMOS compatible.

Waveforms

Figure 2 illustrates how the devices generate the sine waves. A complete sine wave is resolved into 2^{21} phases. The 16-bit data register decides how many of these fractions will be enclosed by two successive clocks (**Fig. 3**). In this way, low values in the 16-bit register produce low frequencies since many of the phases are scanned. High 16-bit values result in high frequencies since many phases are 'ignored'.

The adder and the latch form the phase accumulator that contains the actual phase status. The accumulator is clocked at $f_{CLKIN}/4$. The value stored in the data latch is added to the phase accumulator every 4 cycles of CLK_{IN}. The frequency of the analogue output is equal to the rate at which the accumulator overflows and is given by:

$$f_o = [f_{CLKIN} \times (D_{15} - D_0)_{DEC}] / 2^{23}.$$

Thus, the length of each phase caused by a change of 1 in the content of the register is given by:

$$\Delta f = f_{CLKIN} / 2^{23}.$$

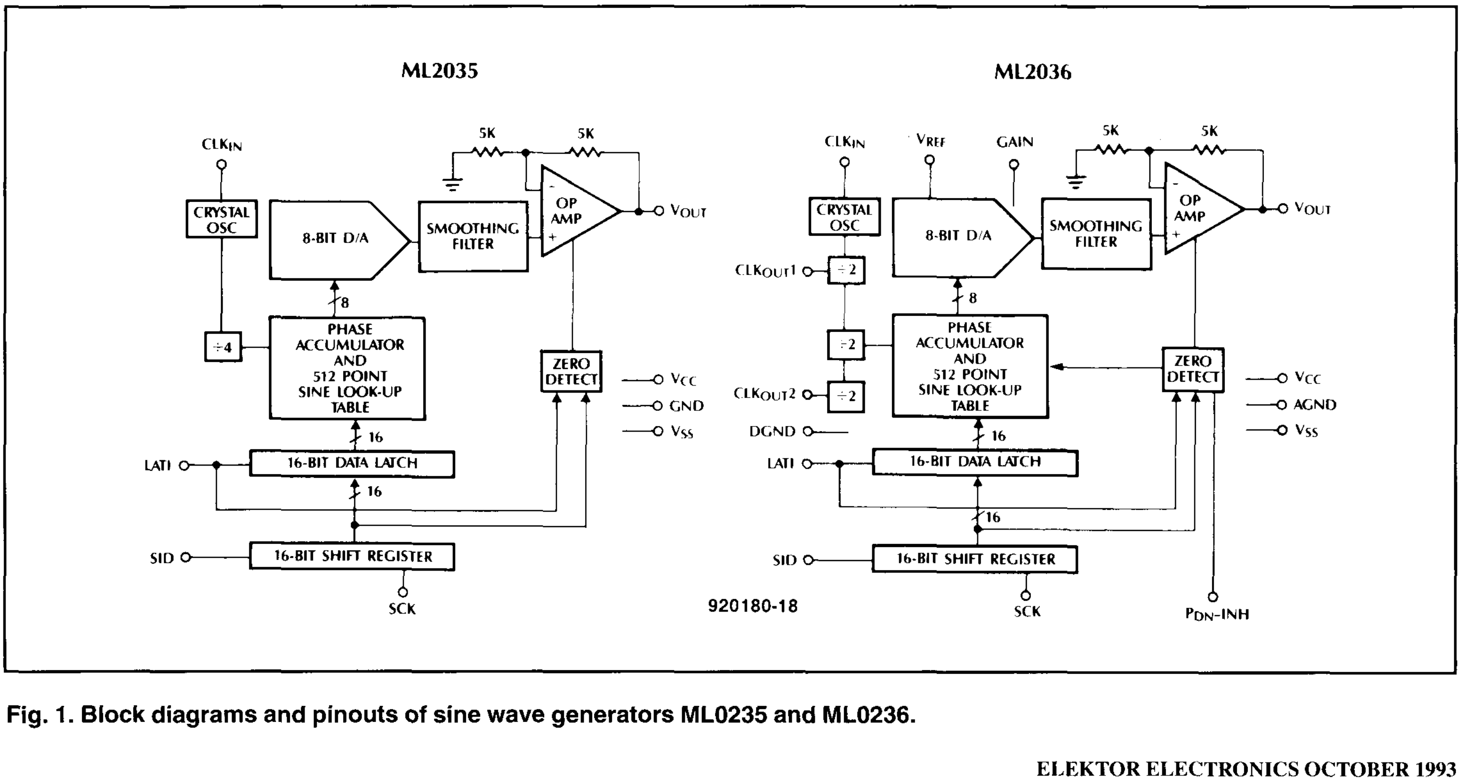


Fig. 1. Block diagrams and pinouts of sine wave generators ML0235 and ML0236.

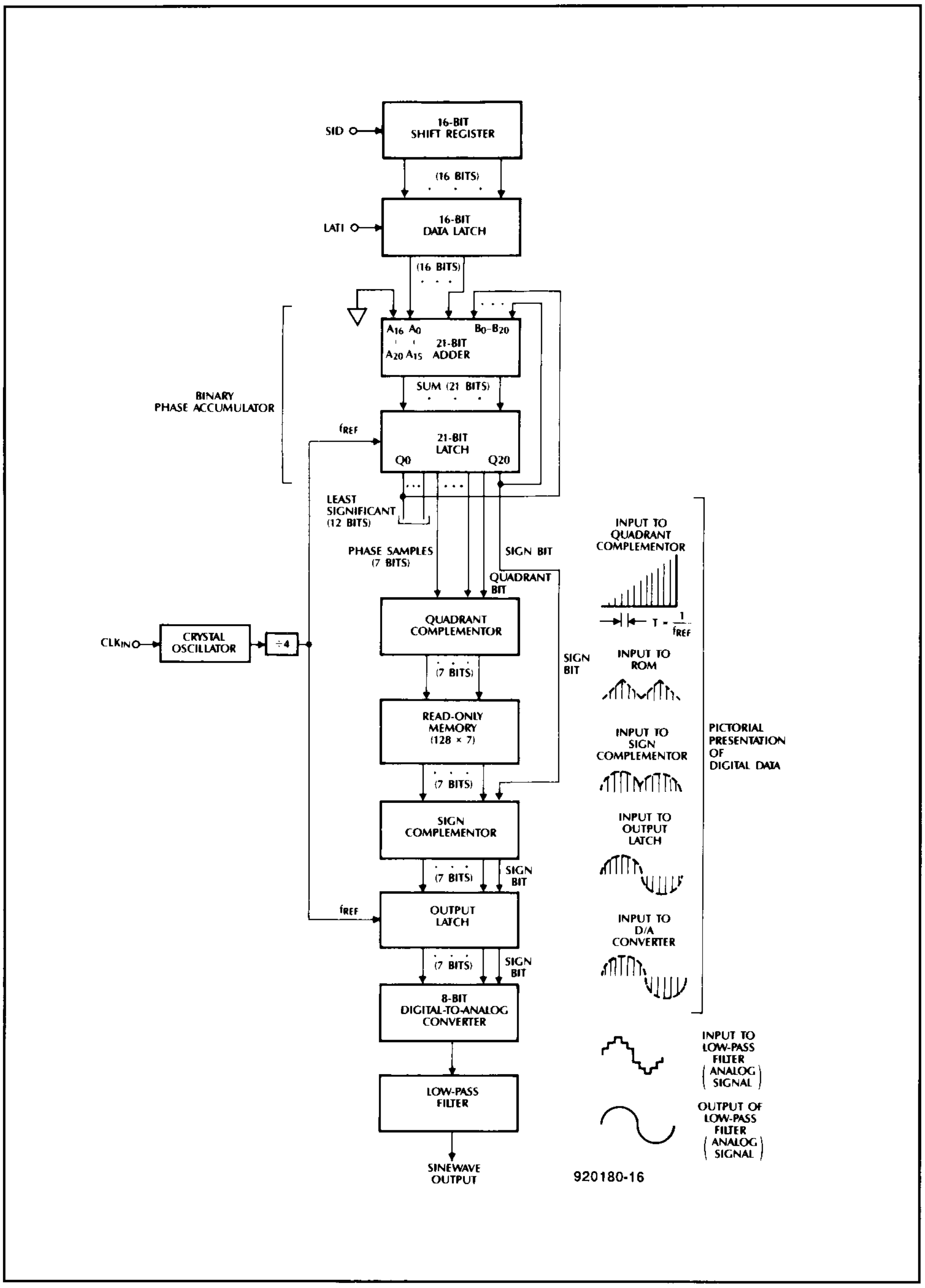


Fig. 2. The functional diagram applies to both devices.

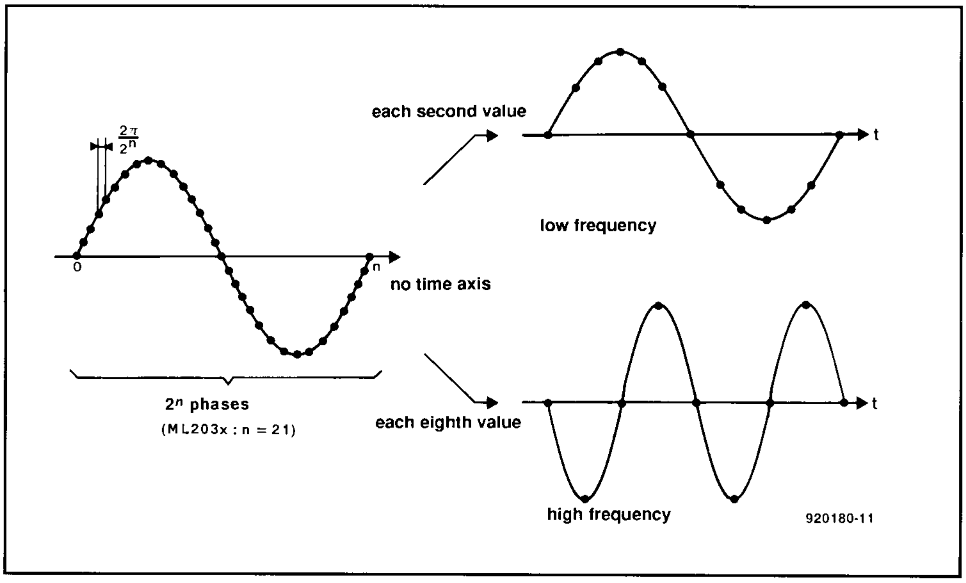


Fig. 3. Sinusoidal signals can be generated from preset digital values.

For instance, if the crystal frequency, f_C, is equal to the clock, f_{CLKIN} of 4.194304 MHz,

$\Delta f = 0.5$ Hz,
and
$f_{o\,(max)} = f_{CLKIN} \times 2^{16}/2^{21} = 32.768$ kHz.

Only the eight highest valued of the 21 bits are processed further; the highest valued bit is the polarity symbol.

Apart from symmetry around the time axis, a sine wave also has symmetry with respect to the peak values of the waveform (**Fig. 4**). This property is used here. With the aid of the second highest bit, the quadrant complementor translates the 7-bit phase value in a manner that a sine look up table with values for 128 phase steps between 0 and $\pi/2$ suffices to compute the output amplitude. The next step in the process is the reemployment of the polarity symbol to ascertain whether a positive or negative half wave must be output (sign complementor). After a second output latch follow the D-A converter and the low-pass filter.

Owing to the phase quantization nature of the frequency generator spurious tones can be present in the output in the range of −55 dB relative to the fundamental. The energy from these tones is included in the signal-to-noise+distortion specification. The frequency of these tones can be very close to the fundamental and it is, therefore, not practical to filter them out.

The sine wave generator comprises a sine look-up table, a DAC, and an output smoothing filter. The sine look-up table is addressed by the phase accumulator. The DAC is driven by the output of the look-up table and generates a staircase representation of a sine wave.

The filter smooths the analogue output by removing the high frequency sampling components. The resultant voltage on V_{OUT} is a sinusoid with all distortion components at least 45 dB below the fundamental.

The ML2035 provides a peak sinusoidal voltage of $\pm V_{CC}/2$. The ML2036 has a V_{REF} input that can be tied to V_{CC} or generated from an external voltage. With the GAIN input equal to a logic 1, the sine wave peak voltage is equal to $\pm V_{REF}$; with the GAIN input equal to a logic 0, the peak voltage is $\pm V_{REF}/2$. The sine wave output is referred to AGND for the

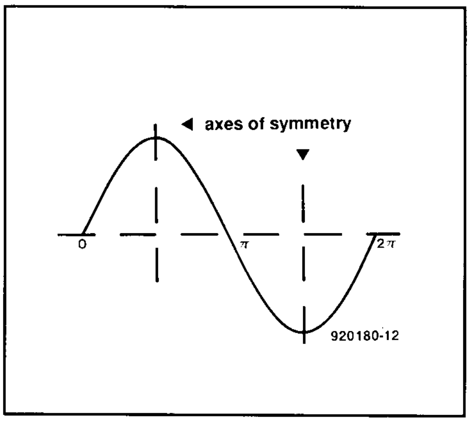


Fig. 4. A sinusoidal signal is symmetrical not only around the time axis, but also with respect to its peak values.

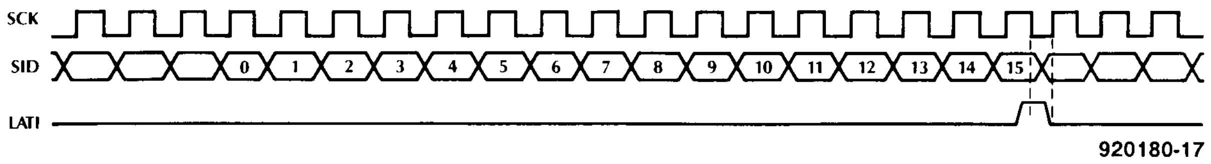


Fig. 5. Serial interface timing.

ML2036 and GND for the ML2035.

Although the analogue section is designed to operate over a range from d.c. to 50 kHz, owing to slew rate limitations, the peak-to-peak output voltage must be limited to $V_{OUT(pp)}$ ≤(125 kV × Hz) / f_{OUT}. For example, on the ML2036 an output of 50 kHz must be limited to 2.5 V_{pp}. Since the ML2035 peak-to-peak output voltage is equal to V_{CC}, the maximum output frequency must be limited to 25 kHz for V_{CC} = 5 V. V_{OUT} can drive 1 kΩ, 100 pF loads and swing to within 1.5 V of V_{CC} and V_{SS}, provided the slew rate limitations mentioned above are not exceeded.

The output offset voltage, V_{OS}, is a function of the peak-to-peak output voltage and is specified as 25 mV + (±10 × $V_{OUT(pp)}$) max. For example, if $V_{OUT(pp)}$ = 2.5 V, V_{OS} = 50 mV max.

The crystal oscillator generates an accurate reference clock for the programmable frequency generator.

The internal clock can be generated with a crystal or an external clock.

If a crystal is used, it must be placed between CLK_{IN} and DGND of the ML2036 or GND of the ML2035. An on-chip oscillator will then generate the internal clock. No other external components are required. The crystal should be a parallel resonant type with a frequency between 3 MHz and 12.4 MHz. It should be placed physically as close as possible to the CLK_{IN} and DGND (or GND). Its maximum equivalent series resistance should be 15 Ω at drive levels of 1–200 µW, or 30 Ω at drive levels of 10 nW to 1 µW. A typical load capacitance is 18 pF. The maximum case capacitance is 7 pF.

The ML2036 has two clock outputs that can be used to drive other external devices. The $\text{CLK}_{OUT}1$ output is a buffered output from the oscillator divided by 2. The $\text{CLK}_{OUT}2$ output is a buffered output from the oscillator divided by 8.

The digital interface consists of a shift register and data latch. The serial 16-bit word on SID is clocked into a 16-bit shift register on leading edges of the serial shift clock, SCK. The LSB should be shifted in first and the MSB last as shown in **Fig. 5**. The data that has been shifted into the shift register is loaded into a 16-bit data latch on the trailing edge of LATI. To ensure that true data is loaded into the data latch from the shift register, LATI trailing edge should occur when SCK is low as shown in **Fig. 1**. LATI should be low while shifting data into the shift register to avoid inadvertently entering the power down mode as described below. Note that all data is entered and latched on edges, not levels, of SCK and LATI.

The power down mode of the ML2035 can be selected by entering all zeros into the shift register and applying a logic 1 to LATI. A zero data detect circuit detects when all bits in the shift register are zeros. In this state, the power consumption is reduced to about 11.5 mW, and V_{OUT} goes to 0 V. The master clock, CLK_{IN}, can be left active or removed during the power down mode.

The ML2036 has an inhibit mode and a power down which are controlled by the three-level P_{DN}-INH input. When a logic 1, V_{13}, is applied to the P_{DN}-INH pin, the power down mode is entered in the same way as described for the ML2035. Also, the ML2036 will be placed in the power down mode by applying a logic 0 to the P_{DN}-INH pin.

If V_{SS} to V_{SS} + 5 V, V_{12}, is applied to the P_{DN}-INH pin, the inhibit mode is entered by shifting all zeros into the shift register and applying a logic 1 to the LATI pin. Once the inhibit mode is entered, V_{OUT} will complete the last half cycle of the sine wave and then be held at about V_{OS}, such that no voltage step occurs.

The analogue circuits in the device are powered from ±5 V (V_{CC} to V_{SS}) and are referred to AGND.

The digital circuits in the device are powered from 0–5 V (V_{CC} to DGND).

For the ML2036, it is recommended that AGND and DGND be connected together close to the device and have a good connection back to the power source.

It is recommended that the power supplies to the device be bypassed by placing decoupling capacitors from V_{CC} to AGND (GND for the ML2035) and V_{SS} to AGND (GND for ML2035) as physically close to the device as possible.

Interfacing

The timing of the serial data input (SID), serial clock (SCK) and the latch input (LATI) is shown in **Fig. 5**. The leading edge of the clock pulses determines the exact instant at which the data are transferred from the SID to the shift register, starting with the LSB and

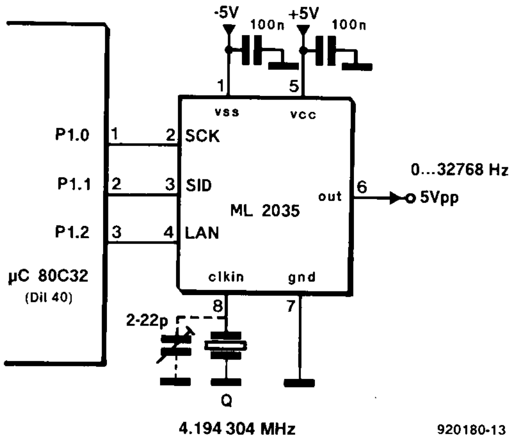


Fig. 6. Application of ML2035.

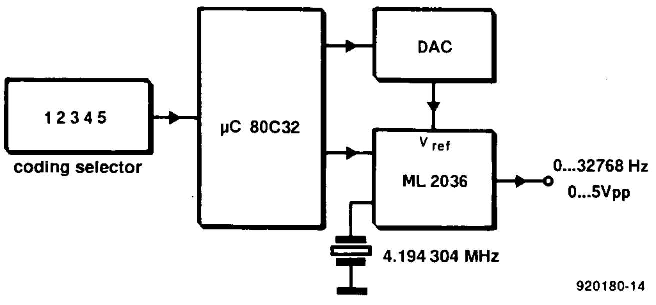


Fig. 7. Block diagram of an ML2036 application.

Call us now! We have the widest range of components available - At competitive prices!

CABLES CAPACITORS VIDEO HEADS SPEAKERS CONNECTORS SEMICONDUCTORS

CRICKLEWOOD
ELECTRONICS

Cricklewood Electronics Ltd. 40 Cricklewood Broadway, London NW2 3ET.
Telephone: 081 452 0161 Faxsimile:081 208 1441

All Major Credit Cards Accepted

DATA COMMUNICATIONS EQUIPMENT (SECOND USER)

GDC 2422 V22 bis 2400 2 wire dial or leased line modem.	65.00
IAL/NEC 96/15 Fast Poll leased line modem	95.00
Racal Milgo 9601 V29 leased line modem with Mux option	85.00
Racal Milgo MPS14.4 leased line modem with Mux option	125.00
Racal Milgo Omnimode 96 single Port leased line modem	75.00
Racal Milgo Omnimode 96 modem with 4 Ch Mux option	85.00
Racal Milgo Sync line drivers SLD1 (Table Top)	45.00
Racal Milgo Sync line drivers SLD1 (Rack Mount)	35.00
Racal Milgo Comlink IV Rack mount module	35.00
Infotron Miniature Async line drivers Type LD/8 19.2K (New)	25.00
Gandalf LDS 309A Limited Distance modem Table top version	30.00
Gandalf 3309A Limited Distance Modem Rack Mount module	27.00
Spectron Patch Chassis DPU-V24 (16 Channels)	299.00
Spectron Patch Chassis UDPU-2400 (16 Channels)	398.00

ALL PRICES EXCLUDE VAT. ADD £7.50 PER ITEM FOR CARRIAGE. (UK ONLY) EXPORT TERMS BY ARRANGEMENT. EVERY ITEM IS FULLY TESTED PRIOR TO DESPATCH AND CARRIES A 90 DAY WARRANTY. INSPECTION OF ANY ITEM PRIOR TO ORDER POSSIBLE BY ARRANGEMENT. MANY OTHER DATA COMS ITEMS AVAILABLE. SEND SAE FOR FULL LISTINGS OF SURPLUS EQUIPMENT.

DUBERY ASSOCIATES

UNIT 1, CHALKCROFT, GREEN STREET GREEN ROAD,
DARTFORD DA2 8DX FAX 0474 707641 TEL 0474 708111

ending with the MSB. During the clocking in, the LATI is logic low (0 V), but, as the diagram shows, it goes high during the last data bit. The trailing edge of the LATI pulse enables the transfer of the data in the shift register to the 16-bit latch. This must happen during the logic low phase of the clock to prevent accidental transfer to the power down state.

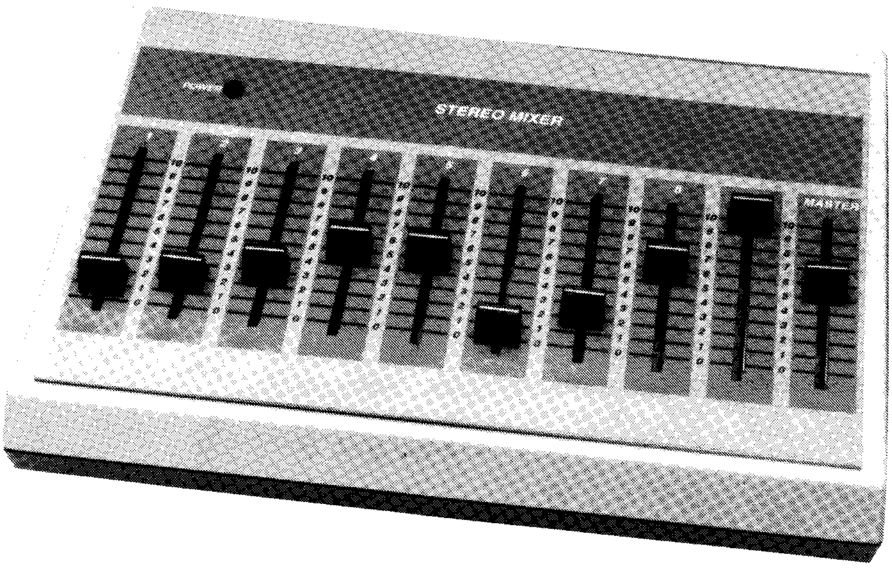
Applications

A practical circuit using the ML 2035 is shown in **Fig. 6**. It is used to set the frequency of an 80C32 microcontroller in steps of 0.5 Hz between d.c. and 32765.5 Hz. Since the crystal oscillates in parallel resonance, the exact frequency can be set with the trimmer across the crystal.

The block diagram in **Fig. 7** is an audio frequency generator with variable output level based on an ML2036. The V_{ref} output of the ML2036 is linked to a D-A converter which presets the output level. **END**

STEREO MIXER

Design by Q. Gregory



The mixer is of modular design so that the constructor can decide how many inputs should be provided

A block diagram of the mixer is shown in **Fig. 2**. Each input has a matching circuit to ensure that the signal source is not unduly overloaded. The output of each input stage may be adjusted to the required level with a (stereo) potentiometer. The outputs of all input stages are combined in a summing amplifier. This amplifier is provided with a (stereo) potentiometer to enable the output level to be matched to the sensitivity of the unit to which the mixer is connected.

The circuit

The circuit of a single input stage is shown in **Fig. 1a** and that of the summing amplifier in **Fig. 1b**.

Referring to the left-hand channel (the right-hand channel is, of course, identical), the input signal is applied to the inverting (–) input of IC_{1a}. The amplification of this stage is $\alpha = -R_2/R_1 = -1$. The minus sign indicates that the stage is an inverting amplifier. The amplification factor, α, may be altered by giving R_2 (and, of course, R_5) a different value.

High-frequency interference signals are prevented from appearing at the out-

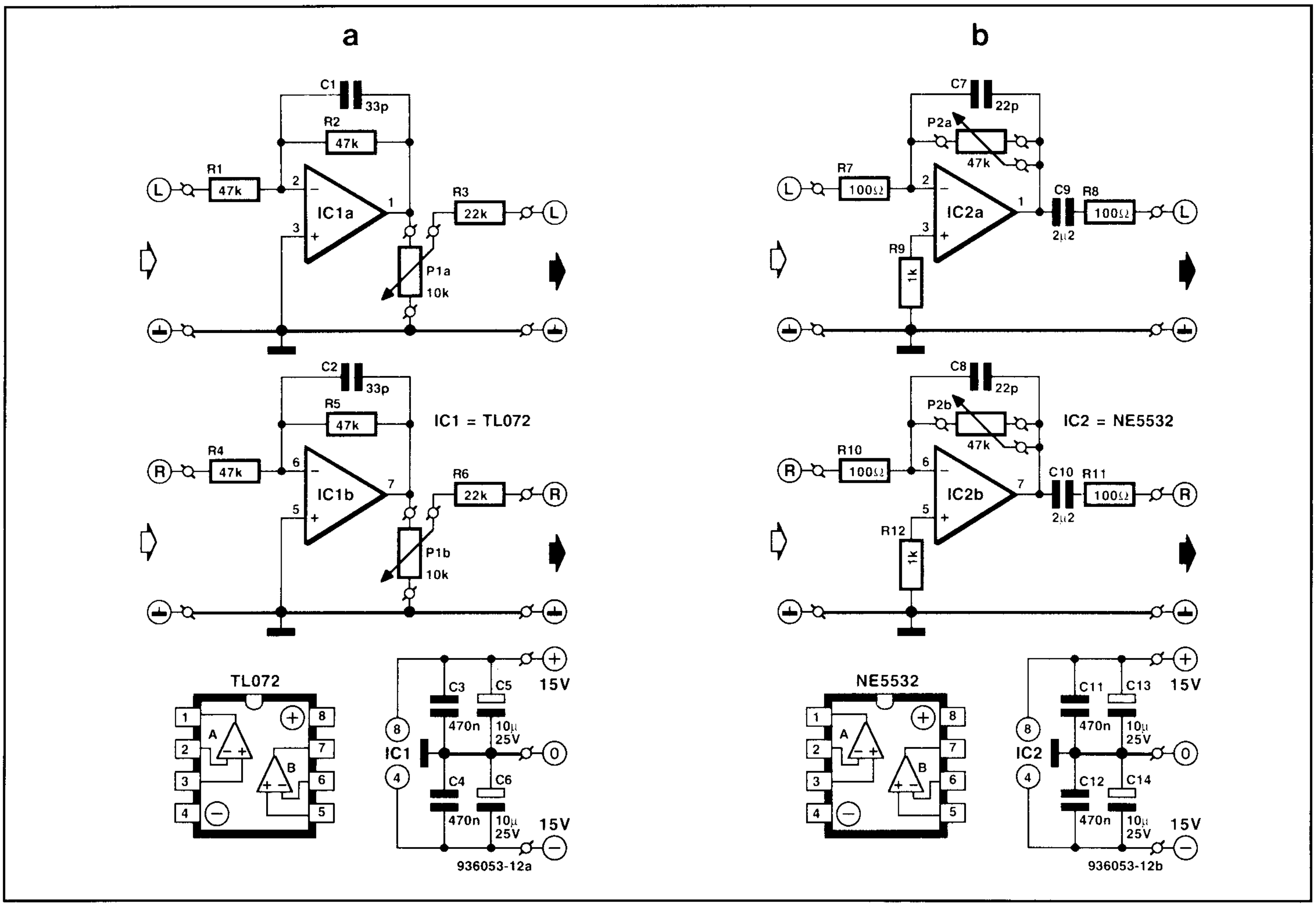


Fig. 1. Circuit diagram of (a) one of the input stages, and (b) the output amplifier.

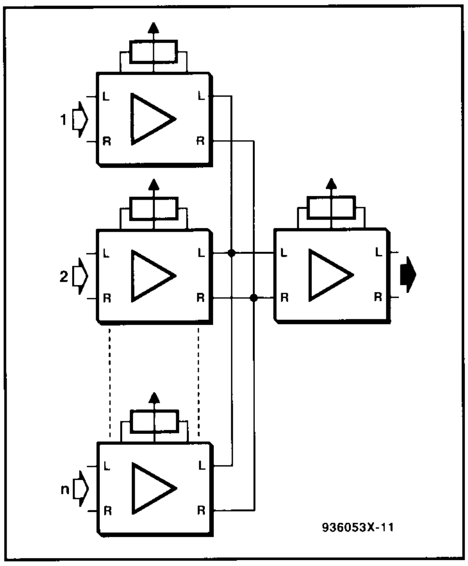


Fig. 2. Block diagram of the stereo mixer.

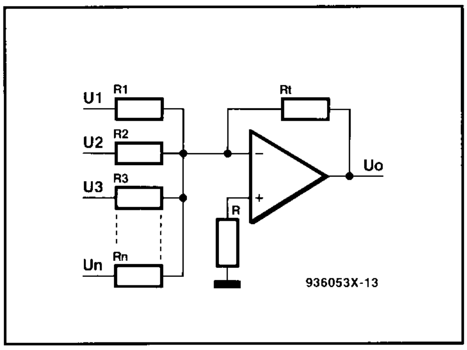


Fig. 3. Simplified representation of the summing circuit.

put (pin 1) by decoupling capacitor C_1. Network R_2-C_1 forms a low-pass filter with a cut-off frequency of around 100 kHz. If the value of R_2 is changed, the cut-off frequency will shift (it is inversely proportional to the change in value of R_2, that is, if R_2 is doubled in value, the cut-off frequency is halved). It is, therefore, advisable not to make R_2 too large, otherwise the cut-off frequency may fall in the audio range (20 Hz to 20 kHz). On the other hand, too low a value of R_2 would shift the cut-off frequency too far upwards.

Circuit IC_2 sums the outputs of all the input stages as shown, simplified, in **Fig. 3**. Its output voltage, U_o, is given by the formula:

$$U_o = -(U_1 + U_2 + U_3 \ldots + U_n),$$

in which *n* is the number of input stages. This formula applies only if all input resistors, R_1, R_2, ... R_n have the same value. In that case, each of the input stages functions as an inverting ×1 amplifier.

As usual, if the value of the feedback resistor, P_2 in **Fig. 1b**, is greater than that of the input resistor, the gain rises above unity. In the present design, the input resistance $(R_3 + R_7) \approx 22\ \text{k}\Omega$, so that the amplification $P_2 / (R_3 + R_7)$ can be varied between 0 and ×2. As in the input stages, the feedback resistor is decoupled by a capacitor (C_7).

The output of the mixer is available after a series *RC* network. The capacitor, C_9, prevents any direct voltage appearing at the output. The resistor, R_8, obviates any tendency to oscillation caused by a capacitive load (such as long screened cables).

The mixer is powered by a regulated ±15 V supply that can provide a current of not less than 100 mA.

PARTS LIST

Resistors:

R_1, R_2, R_4, R_5 = 47 kΩ
R_3, R_6 = 22 kΩ
R_7, R_8, R_{10}, R_{11} = 100 kΩ
R_9, R_{12} = 1 kΩ
P_1* = 10 kΩ, stereo (log or lin)
P_2* = 47 kΩ, stereo, log.

* see text

Capacitors:

C_1, C_2 = 33 pF
C_3, C_4, C_{12} = 470 nF
C_5, C_6, C_{13}, C_{14} = 10 µF, 25 V
C_7, C_8 = 22 pF
C_9, C_{10} = 2.2 µF, 50 V, MKT, pitch 5 mm
C_{11} = 470 nF, pitch 5 mm

Integrated circuits:

IC_1 = TL072
IC_2 = NE5532

Miscellaneous:

Universal boards UPB1 (see p. 70)
Enclosure as required

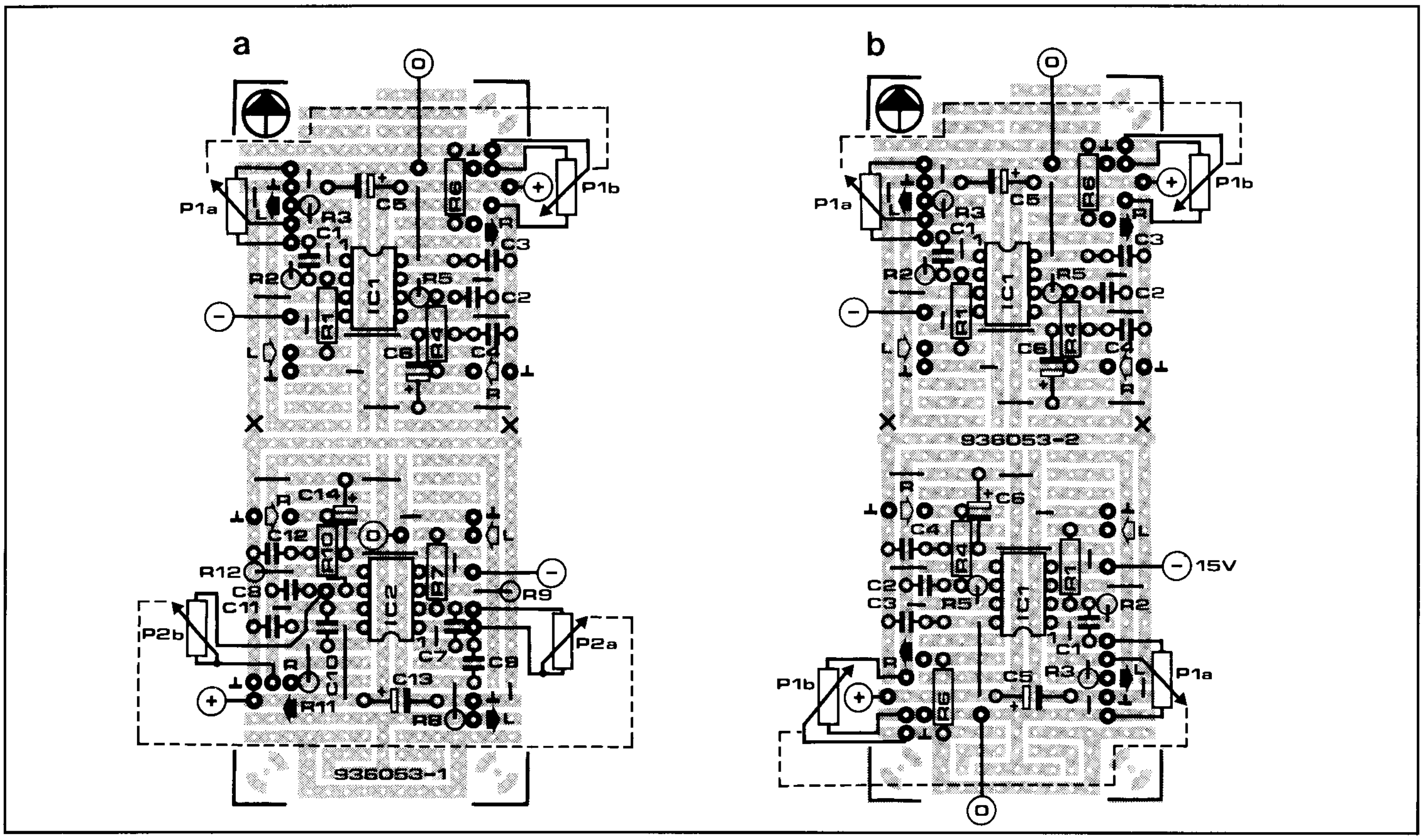


Fig. 4. Construction is best done on a number of universal boards No. UPB1 (see p. 70). At the left, a combination of one stereo input stage and the output stage on one board; at the right, two input stages on another board.

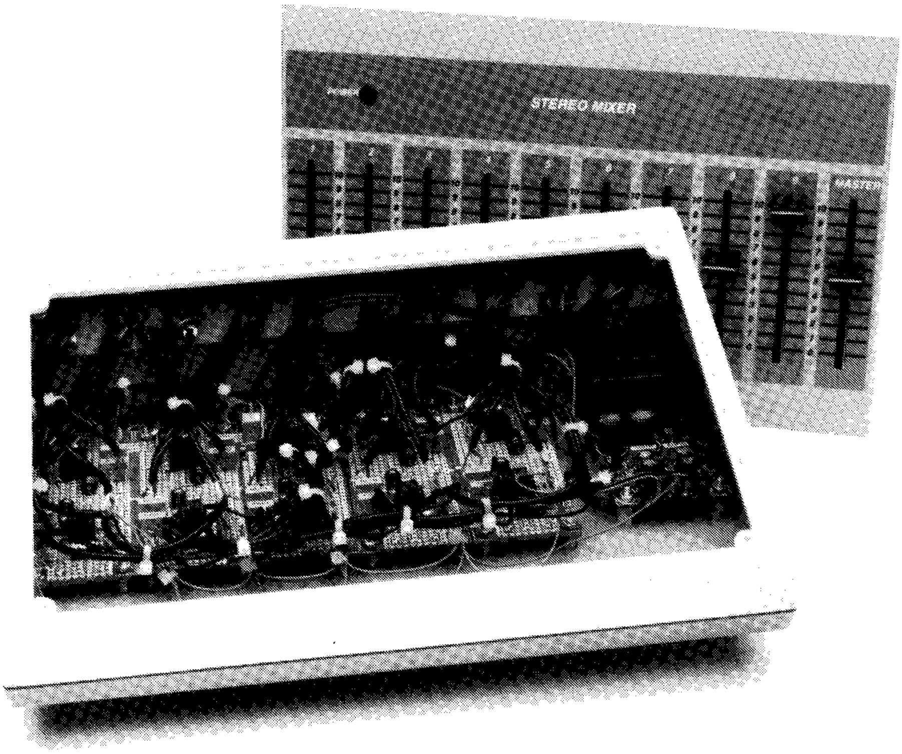


Fig. 5. This photograph shows the large number of screened cables required.

Construction

The prototype has nine stereo input channels, but as already stated, this number is up to individual requirements. If monaural inputs are required, replace P_1 by two mono potentiometers.

The prototype has 10 slide potentiometers (one for the output stage). One input stage and the summing amplifier can be built on a universal board (UPB 1) as shown in **Fig. 4**. Further input stages can be built, in pairs, on the same type of board. The prototype thus uses five of these boards.

Start by laying the wire bridges. Use sockets for the ICs so that these can be replaced easily if and when required. Use PCB pins for all external connections because, as will be seen during the construction, these are indispensable at a later stage.

When all boards and the power supply have been constructed, they can be assembled in a suitable enclosure (the best is one with a slanting front panel specially designed for mixers).

The use of slide potentiometers is strongly recommended, because these show at a glance the setting of each channel. This type of control is dearer than a rotary control and it also has the disadvantage of requiring a slot rather than just a round hole. Fit the (slide) potentiometers to the front panel on short spacers.

Next, drill the holes in the rear panel for the audio sockets (**Fig. 7**) and fit the sockets with their earth terminal at the top. If a metal enclosure is used, the sockets should be insulated from it to obviate earth loops.

Fit the boards and the power supply in the enclosure. Keep the supply as far away from the inputs as possible to minimize the risk of mains hum. Fit the mains input cable with a strain relief.

All audio connections must be made in screened cable (**Fig. 5**) to minimize any hum pick-up. There are thus four screened cables to the potentiometer in each input stage. The earth terminal of each stereo potentiometer must be connected to the screen of the cable. Interconnect the screens of the left-hand and right-hand channels and solder the joints to the ground terminals

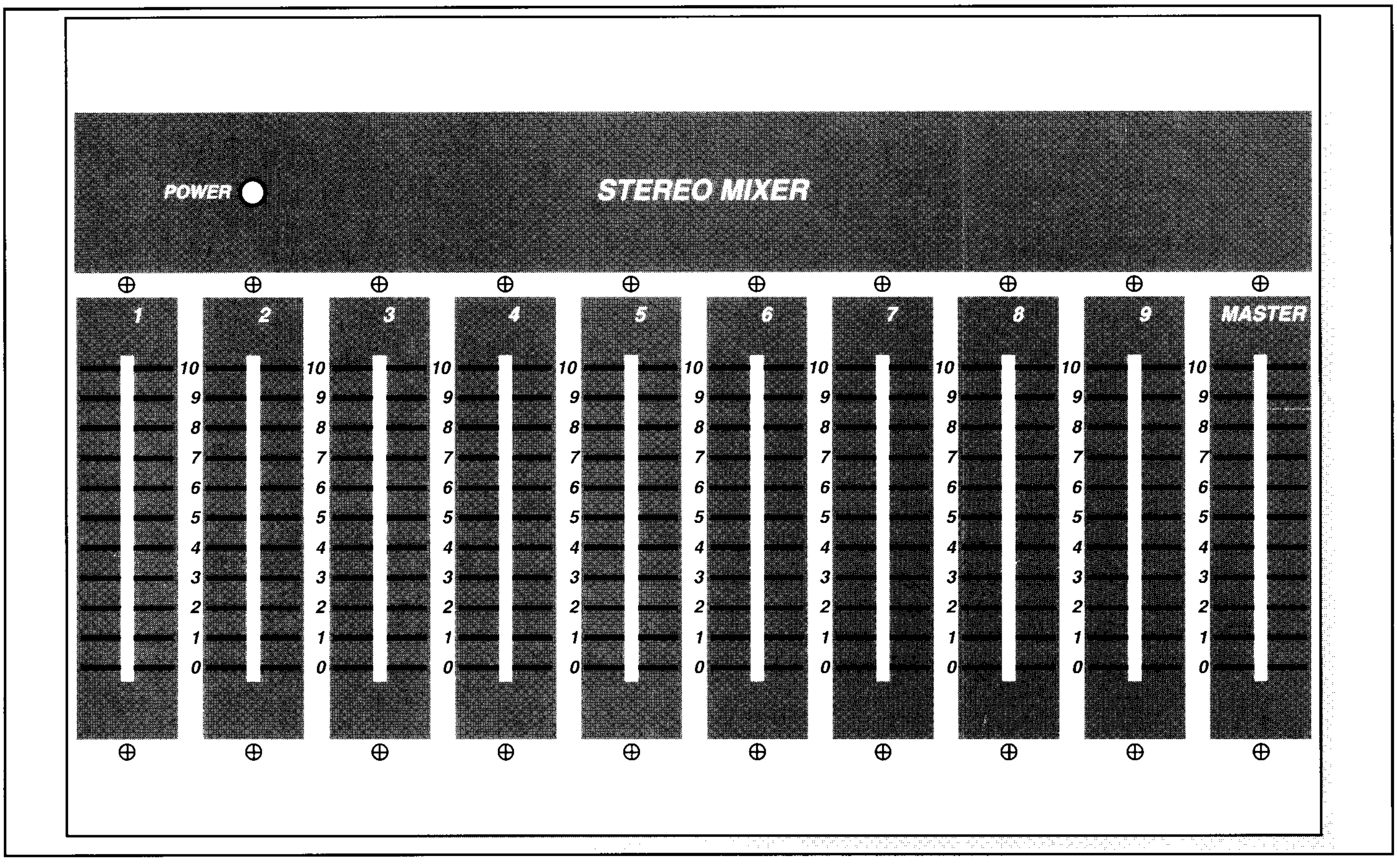


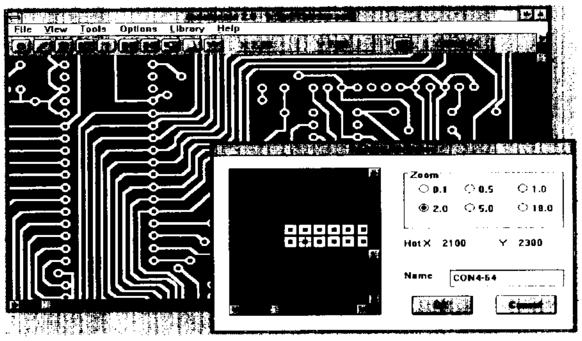
Fig. 5. Proposed front panel (scale 1:1) for the stereo mixer.

Please mention **ELEKTOR ELECTRONICS** *when contacting advertisers*

"... there is no doubt that running under *Windows* puts it ahead of the field and makes it a visually attractive package." Electronics World + Wireless World July 1993

High Quality PCB and Schematic Design for Windows 3/3.1 and DOS

- Supports over 150 printers/plotters including 9 or 24 pin dot-matrix, DeskJet, LaserJet, Postscript, and HPGL. Professional Edition imports GERBER files, and exports GERBER and NC-DRILL files.
- Up to 200,000 pads/track nodes depending on memory. Simple auto-router and schematic capture tools with SPICE compatible net-list output.
- Low cost DOS version (reduced features) also available. Ring for full details!



"Quickroute provides a comprehensive and effective introduction to PCB design which is a pleasure to use" Radio Communication May 1993.

Quickroute

POWERware Software • Design

POWERware, Dept EK, 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD, UK.
Ring us on 061 449 7101 or write, for a full information pack.

Quickroute is available for Windows 3/3.1 in Professional (£99.00) and Standard (£59.00) editions, and for DOS with reduced features (£39.00). All prices inclusive. Add £5 P+P outside UK.

from **£39**

on the board.

The potentiometer in the summing amplifier needs to be connected by only two screened cables, because its wiper is linked to one of its other terminals.

The (already good) signal-to-noise ratio may be improved further by the use of metal film resistors instead of carbon types. Also, use conductive-plastic type slide potentiometers instead of carbon types. Furthermore, it may be necessary to fit the power supply in a separate enclosure.

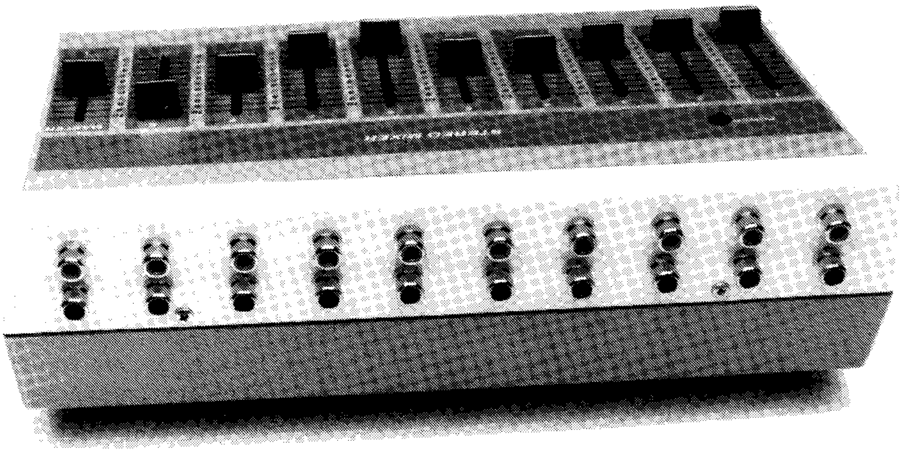


Fig. 7. Recommended way of mounting the audio sockets on the rear panel.

Testing

Connect the mixer to a suitable output amplifier (and speakers) and apply an audio signal to each input in turn. Set the master volume control half-way and check that the volume of input can be adjusted between nil and maximum.

When this is so, check that the volume of the composite signal can be adjusted as required with P_2. If the sound increases too rapidly, it is likely that this potentiometer has been connected the wrong way around (since this control has a logarithmic characteristic, it can be connected correctly in only one way). This error is remedied by connecting the wiper of P_2 to the other terminal and turning the control around (180°). **END**

FIGURING IT OUT

PART 9 – REACTIVE NETWORKS

By Owen Bishop

This series is intended to help you with the quantitative aspects of electronic design: predicting currents, voltage, waveforms, and other aspects of the behaviour of circuits. Our aim is to provide more than just a collection of rule-of-thumb formulas. We will explain the underlying electronic theory and, whenever appropriate, render some insights into the mathematics involved.

Last month we used complex numbers for circuit analysis, but reverted to using Pythagoras and inverse tangents for evaluating the final result. What we need to do next is to formalize this process. We represent a given complex number z by a point in the complex number plane, quoting its coordinates (a, b) in the form

$$z = a + \mathbf{j}b. \qquad \text{[Eq.55]}$$

These are rectangular coordinates, and the complex number is said to be expressed in **rectangular form**. Another way of specifying the position of a point in a plane is to give its **polar coordinates**. The relationship between the two kinds of coordinate is shown in **Fig. 77**. In this figure:

$$a = r \cos \theta; \qquad \text{[Eq. 56]}$$
$$b = r \sin \theta. \qquad \text{[Eq. 57]}$$

Substituting in Eq. 55 we find:

$$z = r \cos \theta + \mathbf{j}r \sin \theta,$$

or

$$z = r (\cos \theta + \mathbf{j} \sin \theta). \text{ [Eq. 58]}$$

This is the **polar form** of z. The only essential pieces of information in this formula are the radius r and the angle θ. We adopt a shorter way of writing out the polar form by quoting r and θ, but leaving out the 'cos' and 'jsin', which are taken as understood, all complex numbers having the same format. This leaves us with:

$$z = r \angle\theta, \qquad \text{[Eq. 59]}$$

which means the same thing as Eq. 58, but is much quicker to write and much easier to comprehend. In this expression, we refer to r as the **modulus** and to θ as the **argument** of the complex number.

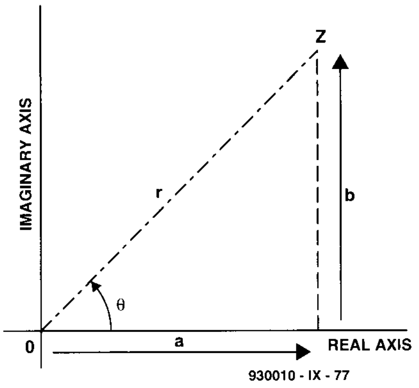


Fig. 77.

Conversions

The two final examples last month showed how to convert from rectangular form to polar form. Given $z = a + \mathbf{j}b$, we calculate:

$$r = (a^2 + b^2)^{1/2}$$

and

$$\theta = \tan^{-1}(b/a),$$

and write the result in the form of Eq. 59. There is a slight problem, which is that there are two possible values of an inverse tangent. These are 180° apart. A simple sketch or inspection of the signs of a and b tells us the quadrant in which z is situated.

Example: convert $z = -4 - \mathbf{j}5$ into polar form. First find

$$r = (4^2 + 5^2)^{1/2} = 6.40.$$

Next, find

$$\tan^{-1}(-5/-4) = 51.34°.$$

But both a and b are negative, so the point must be in the third quadrant. This means that $\theta = 180 + 51.34 = 231.34°$. The result:

$$z = 6.40 \angle 231.24°.$$

Converting from polar form to rectangular form uses Eq. 56 and 57, the result being written in the form of Eq. 55.

Example: convert $z = 50 \angle 36°$ into rectangular form

$a = 50 \cos 36° = 40.45;$
$b = 50 \sin 36° = 29.39.$

Result: $z = 40.45 + \mathbf{j}29.39$.

Most scientific calculators have both conversions as built-in programs. Their usefulness depends on the fact that adding and subtracting complex numbers is easier when they are in rectangular form, but multiplying and dividing is easier when they are in polar form. In the course of an analysis we may convert from one form to the other and back again several times, according to which operation is currently required.

The rule for multiplication is: **multiply the moduli, sum the arguments**.

Example: multiply $4 \angle 60°$ by $2 \angle 10°$. Multiply moduli: $4 \times 2 = 8$. Sum the arguments: $60° + 10° = 70°$. Result: $8 \angle 70°$.

Conversely, the rule for division is: **divide the moduli, find the difference between the arguments**. This short, easily remembered form of the rule does not specify which modulus to divide by which, or which argument to subtract from which, but commonsense applies, as in this example: divide $6 \angle 85°$ by $2 \angle 40°$. Divide moduli: $6/2 = 3$. Difference of arguments: $85 - 40 = 45$. Result: $3 \angle 45°$.

Network analysis

Figure 78 shows a reactive network in which we are required to find the voltages and currents for all components. The applied signal has a peak value of 200 V and the frequency is 3183 Hz. We begin by rewriting the capacitance as a complex impedance:

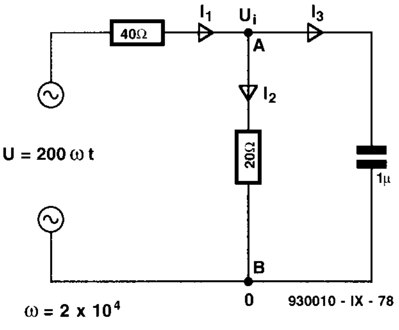


Fig. 78.

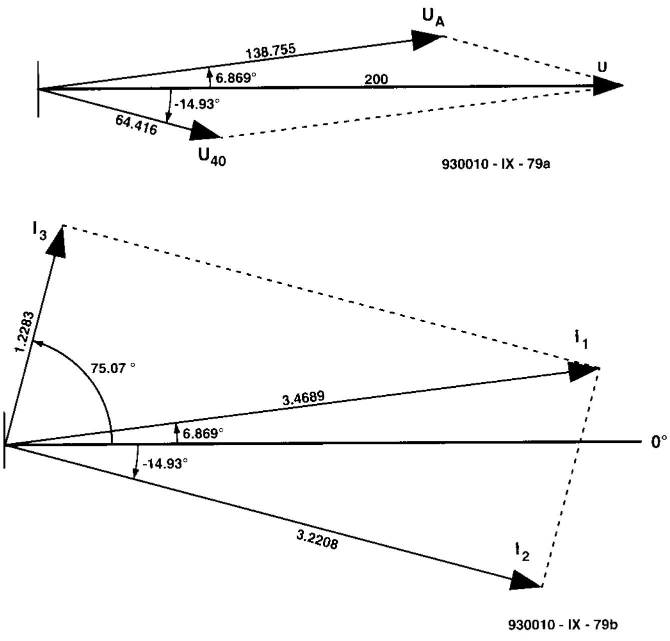


Fig. 79.

$X_C = -j\omega C = -j50.$

Taking node B to be at 0 V, and considering node A at U_A V, by KCL:

$I_1 + I_2 + I_3 = 0,$
or

$$\frac{U_A-200}{40}+\frac{U_A}{20}+\frac{U_A}{-j50}=0$$

since $I = U / X$ for each component. This equation is simplified:

$$U_A\left(\frac{3}{40}+\frac{1}{-j50}\right)=5$$

$$U_A\left(\frac{-j150+40}{-j2000}\right)=5$$

$$U_A=\frac{-j10000}{40-j150}.$$

Here we have to divide one complex number by another: convert to polar form and divide:

$$U_A = \frac{10000\angle-90^\circ}{155.24\angle75.07^\circ}$$
$$= 64.416\angle-14.93^\circ.$$

Having found U_A, we know the pd across the 20 Ω resistor and the capacitor, but need to find the pd across the 40 Ω resistor. Since we are, as usual, taking the applied voltage as the reference for phase angle, the polar form of this is $200\angle0^\circ$. Calculating U_{40}:

$$U_{40} = 200\angle0^\circ - 64.416\angle-14.93^\circ.$$

Here we have to subtract: convert to rectangular form:

$$U_{40}=(200+j0)-(62.241-j16.596)$$
$$=137.759+j16.596.$$

Convert the result back to polar form to express it as a phasor:

$$U_{40} = 138.755\angle6.869^\circ.$$

Now that we have the pd across all components, we calculate the currents:

$$I_1 = (138.755\angle6.869^\circ)/40$$
$$= 3.4689\angle6.869^\circ;$$

$$I_2 = (64.416\angle-14.93^\circ)/20$$
$$= 3.2208\angle-14.93^\circ;$$

$$I_3 = (64.416\angle-14.93^\circ)/50\angle-90^\circ$$
$$= 1.2883\angle75.07^\circ.$$

If you try to convert a number such as –j50 into polar form with a calculator, you will probably get an error message. This is because you are asking the calculator to evaluate $\tan^{-1}(-50/0)$. But we know that the '–j' means 'turn 90° clockwise', so the conversion may be written out directly as $50\angle-90^\circ$, as in the equation for I_3.

j in determinants

Simultaneous equations that include complex numbers can be solved by determinants with the method explained in Part 4. **Figure 80** is an example of mesh analysis in which we are required to find the value of I_1. The complex impedances are stated beside each component.

As usual, we write an equation for each mesh, including the complex impedances of the capacitor and the inductor:

$$I_1(8-j5) - I_2(8) = 50 + j0;$$

$$-I_1(8) + I_2(8+j4) = 0.$$

The righthand side of the first equation expresses the applied voltage in rectangular form. This simplifies to just 50.

Following the technique described in Part 4, we write the determinant equation for I_1:

$$I_1=\frac{\begin{vmatrix}50 & -8\\ 0 & 8+j4\end{vmatrix}}{\begin{vmatrix}8-j5 & -8\\ -8 & 8+j4\end{vmatrix}}.$$

The value of the determinant in the numerator is

$$50\,(8+j4) - 0 = 400 + j200.$$

The value of the determinant in the denominator is

$$(8-j5)(8+j4) - 64$$
$$= 84 - j8 - 64 = 20 - j8.$$

Multiplying (8 – j5) by (8 + j4) could be done after converting them to polar form but, with such small coefficients, a straightforward algebraic multiplication is easier. The equation for I_1 simplifies to a quotient:

$$I=\frac{400+j200}{20-j8}$$
$$=\frac{447.214\angle26.5651^\circ}{21.5407\angle-21.801^\circ}$$
$$=20.76\angle48.37^\circ$$

We convert to polar form to evaluate the quotient and state the result in polar form. The peak current in Mesh 1 is 20.76 A, clockwise, leading the applied voltage by 48.37°.

The complex numbers in the determinants of this example are few and simple, but they illustrate the point that determinants may include complex numbers without altering the essential routine of the mesh analysis.

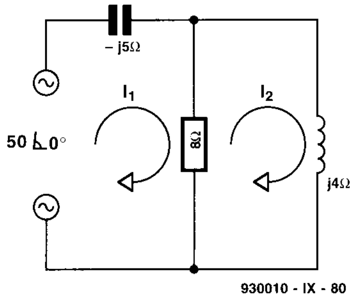


Fig. 80

Thevenin equivalent

The complex Thevenin equivalent is calculated in the same way as described in Part 3, but using complex numbers. As an example, we calculate the Thevenin voltage, U_{TH}, and impedance, Z_{TH}, between terminals A and B of the network of **Fig. 81**. In this figure, U_{TH}, defined as the open-circuit voltage, is the voltage across the 4 Ω resistor and the inductor; there is no pd across the 2 Ω resistor, because the circuit between A and B is open. If I is the current circulating in the loop:

$$U_{TH} = I\,(4+j3)$$
$$= \frac{10\angle0^\circ}{4-j2+j3}\times(4+j3)$$
$$=12.127\angle22.835^\circ.$$

The reader may like to verify the intermediate stages of this calculation.

The Thevenin impedance is calculated with the second method from Part 3, in which we replace the voltage source by a short circuit and then apply the technique of network reduction. The network is then equivalent to 4 Ω and j3 Ω in series, in parallel with –j2 Ω, and this is in series with 2 Ω.

$$Z_{TH}=\frac{(4+j3)(-j2)}{4+j3-j2}+2$$
$$=\frac{6-j8}{4+j}+2$$
$$=\frac{6-j8+8+j2}{4+j}$$
$$=\frac{14-j6}{4+j}$$
$$=3.694\angle-37.235^\circ.$$

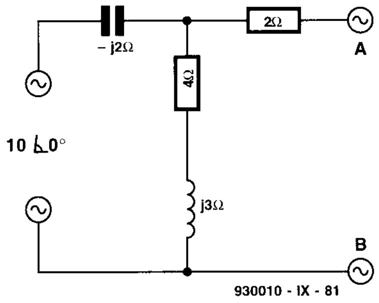


Fig. 81.

Filters

Of all types of circuit, filters are those most concerned with the effects of varying frequency. Consequently, complex numbers are invaluable for analysing filter circuits. We begin with the simplest possible example, a low-pass *RC* passive filter (**Fig. 82**). Treating this as a potential divider, and assuming that the load current is negligible, we arrive at the ratio

$U_{out}/U_{in} = X_C/(R + X_C)$. [Eq. 60]

Writing the capacitor reactance as a complex number:

$$U_{out}/U_{in} = \frac{1/\mathbf{j}\omega C}{R + 1/\mathbf{j}\omega C}$$

Multiplying throughout by $\mathbf{j}\omega C$:

$U_{out}/U_{in} = 1/(\mathbf{j}\omega RC + 1)$. [Eq. 61]

For example, given that $\omega = 10^5$ (f = 15,915 Hz), R = 1 kΩ, and C = 10 nF, we find that $\omega RC = 1$. The expression reduces to

$$\begin{aligned} U_{out}/U_{in} &= 1/(\mathbf{j} + 1) \\ &= 1/1.414 \angle 45° \\ &= 0.707 \angle{-45°}. \end{aligned}$$

The output voltage is reduced to 0.707 of the input voltage and there is a phase lag of 45°. The frequency on which this example is based is the –3 dB point of the filter. Let us see what happens if we double the frequency but keep component values unchanged. Now, $\omega RC = 2$ and:

$$\begin{aligned} U_{out}/U_{in} &= 1/(\mathbf{j}2 + 1) \\ &= 1/2.236 \angle 63.43° \\ &= 0.447 \angle{-63.43°}. \end{aligned}$$

The output voltage is smaller, showing that this is a low-pass filter, and the phase lag is increased. Note that when the frequency becomes higher, the effect of the '1' in the denominator becomes relatively less. Doubling of frequency approximately halves the output voltage; in other words, output falls at the rate of 6 dB per octave.

This technique is for calculating output and phase lag for any passive *RC* filter at any frequency.The same principles are applicable to a high-pass filter (with *R* and *C* interchanged) or to an *LC* filter.

The performance of the filter is affected if there is an appreciable load on it. In **Fig. 83**, the load resistor is in parallel with the capacitor. Their parallel impedance is

$Z_{CL} = X_C/R_L/(X_C + R_L)$. [Eq. 62]

Substituting Eq. 62 in Eq. 60:

$$U_{out}/U_{in} = Z_{CL}/(R + Z_{CL}).$$

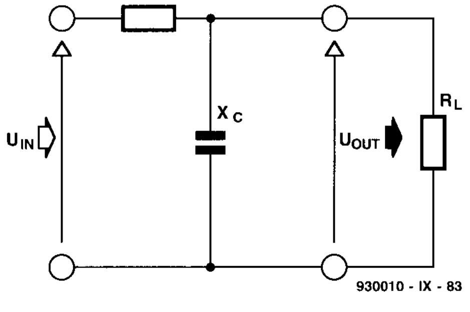


Fig. 83.

Omitting intermediate steps, we arrive at a useful result:

$U_{out}/U_{in} = 1/(1 + R/R_L + \mathbf{j}\omega RC)$. [Eq. 63]

If R_L is infinitely large, this equation reduces to Eq. 61, which is to be expected. As an example, keep other values unaltered and make R_L = 10 kΩ, with $\omega = 10^5$, as in the first filter example:

$$\begin{aligned} U_{out}/U_{in} &= 1/(1 + 0.1 + \mathbf{j}) \\ &= 1/(1.1 + \mathbf{j}) \\ &= 1/1.487 \angle 42.27° \\ &= 0.672 \angle{-42.27°}. \end{aligned}$$

The output voltage and phase lag are both reduced slightly by a 10 kΩ load.

The approach used above may be applied to the analysis of active filters, in which operational amplifiers are employed. The analysis is more involved than that for a passive filter, but the same principles apply and, as far as the topic of complex numbers is concerned, there is nothing new to add.

Test yourself

1. Multiply (2 + **j**3) by (5 – **j**4) in rectangular form. Then convert them both to polar form and multiply them in this form. Convert the product back to the rectangular form to confirm that the 'multiply/sum' rule is true.
2. Divide (4 + **j**7) by (2 – **j**3) in rectangular form. Convert to polar form and divide. Convert back to rectangular form to confirm that the 'divide/difference' rule is true.
3. Confirm the correctness of the analysis of **Fig. 76** by converting the currents into rectangular form and checking that $I_1 = I_2 + I_3$.
4. Find the current passing through the resistor in **Fig. 78** (beware inverse tangents).
5. Given a low-pass filter as in **Fig. 81**, but with R = 100 Ω, C = 10 μF and f = 400 Hz, calculate U_{out}/U_{in} and the phase angle. What is the effect of feeding the output to a resistive load of 4 kΩ?

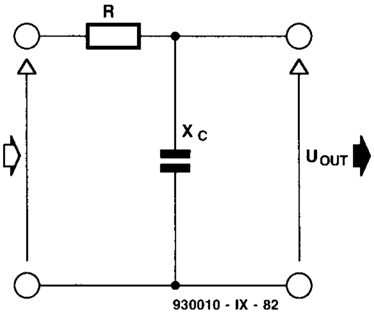


Fig. 82.

Exponential form

While on the subject of representing complex numbers, the **exponential form** is useful in some applications. The relationship between this and the polar form is:

$r \angle \theta = re^{\mathbf{j}\theta}$.

In this equation, θ must be expressed in radians. One advantage of the exponential form is that it makes it possible to take logarithms of complex numbers. Another advantage, more important from the electronic point of view, is that this form is more amenable to the Laplace transformation. This is a topic that we shall deal with in later issue.

TO BE CONTINUED

Answers to
Test yourself (Part 8)

1. 9 + **j**5.
2. 10 – **j**3.
3. 1.6 – **j**2.6.
4. 1 + **j**8.
5. 9 + **j**37.
6. 18 – **j**4.
7. 4 – **j**5.
8. 0.466 + **j**0.086.
9. ω = 314.2; X_L = **j**31.42 Ω; X_C = –**j**67.72 Ω; I_R = 0.00833U; I_L = –**j**0.0318U; I_C = **j**0.0148U; I = 0.0189U, lagging by 63.9°. Currents in amperes.
10. ω = 942.5; X_L = **j**94.25 Ω; X_C = –**j**22.59 Ω; I_R = 0.00833U; I_L = –**j**0.0106U; I_C = **j**0.0443U; I = 0.0337U, leading by 76.1°. When t = 2 s, U = 88.8 mV, I = 2.99 mA.

At last, a fully functional upgradeable PCB CAD system to suit any budget. Substantial trade-in discounts are available against other "professional" PCB design packages ...

... call now for details.

BoardCapture

Schematic Capture Design Tool

£395

- Direct netlist link to BoardMaker2
- Forward annotation with part values
- Full undo/redo facility (50 operations)
- Single sheet, multi-paged and hierarchical designs
- Smooth scrolling
- Intelligent wires (automatic junctions)

- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
- Extensive component-based power control
- Back annotation from BoardMaker2

BoardMaker

BoardMaker1 - Entry level

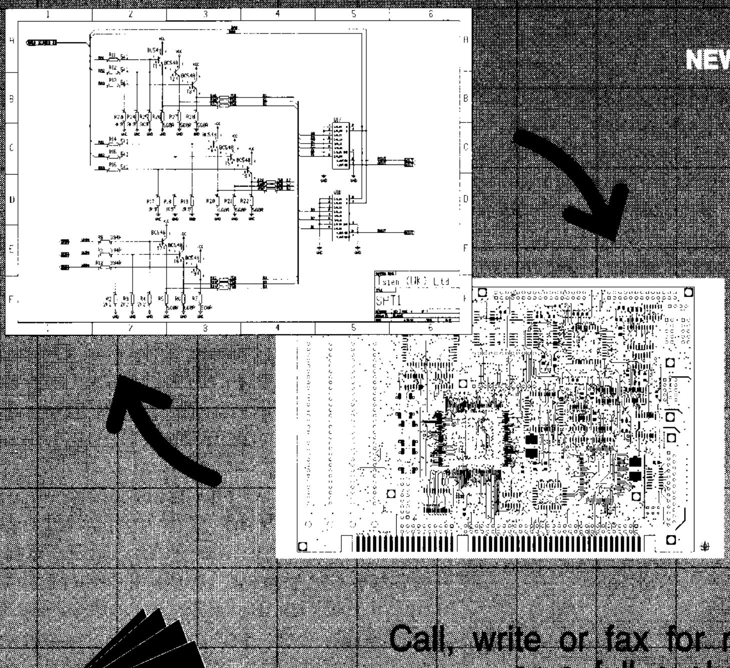
£95

- PCB and schematic drafting
- Easy and intuitive to use
- Surface mount and metric support
- 90, 45 and curved track corners
- Ground plane fill
- Copper highlight and clearance checking

BoardMaker2 - Advanced level

£295

- All the features of BoardMaker1 +
- Full netlist support - BoardCapture, OrCad, Schema, Tango, CadStar and others
- Full Design Rule Checking both mechanical and electrical
- Top down modification from the schematic
- Component renumber with back annotation
- Report generator - Database ASCII, BOM
- **NEW** Thermal power plane support with full DRC



BoardRouter

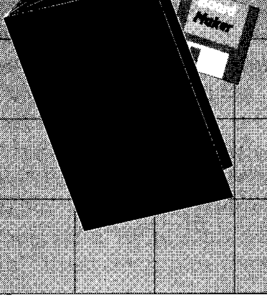
Gridless re-entrant autorouter

£200

- Simultaneous multi-layer routing
- SMD and analogue support
- Full interrupt, resume, pan and zoom while routing

Output drivers - Included as standard

- Printers - 9 & 24 pin Dot matrix, HPLaserjet and PostScript
- Penplotters - HP, Graphtec & Houston
- Photoplotters - All Gerber 3X00 and 4X00
- Excellon NC Drill and Annotated drill drawings (BM2)



Call, write or fax for more information
or a full evaluation kit
Tsien (UK) Limited
Aylesby House
Wenny Road, Chatteris
Cambridge
PE16 6UT
Tel (0354) 695959
Fax (0354) 695957

tsien

All trademarks acknowledged

AUTORANGING FREQUENCY READOUT

The frequency meter described here has a maximum input frequency of about 2 MHz, and is ideal for building into function generators and similar instruments, where it gives a far more accurate frequency indication than the traditional frequency dial.

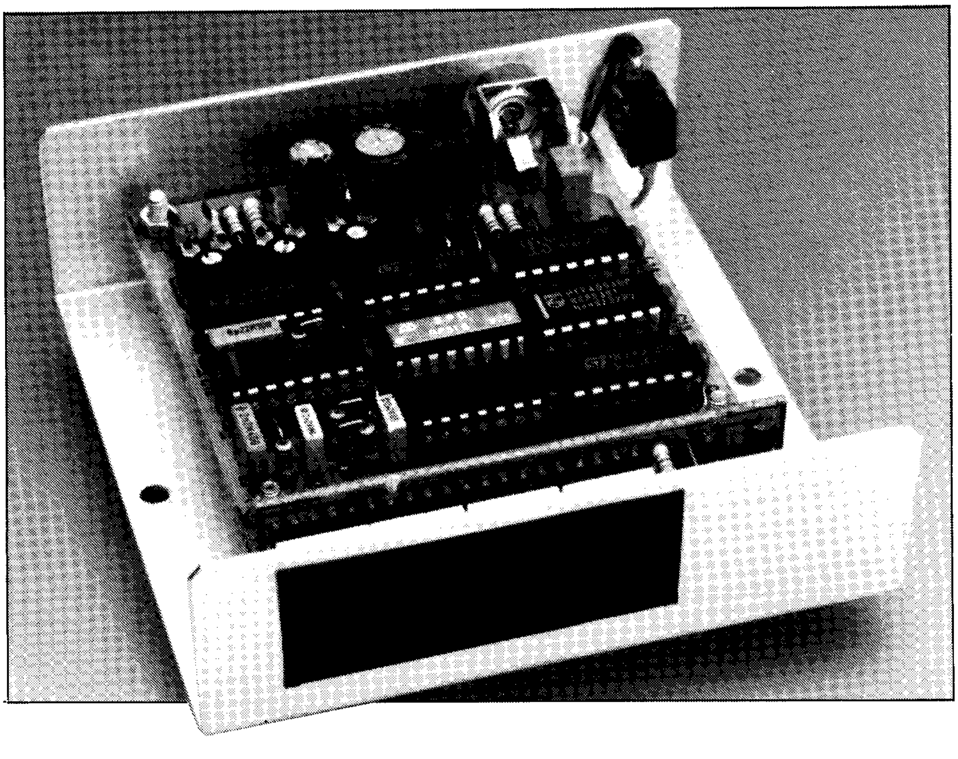
Design by H. Kühne

FREQUENCY scales on sine-wave generators, function generators and pulse generators are usually mechanically coupled, and by no means accurate enough for many applications. Even if the scale is individually calibrated, it is not always easy to accurately set the desired frequency. Not surprisingly, an increasing number of generators is fitted with an internal frequency meter that functions as a frequency scale, or read-out. Today's electronics technology allows this to be achieved fairly easily. However, building a frequency meter into an existing generator can throw up some unexpected problems. Lack of space on the front panel, for instance, may force you to limit the number of display digits (the present circuit has only four). This, in turn, limits the measurement range. The obvious solution to this problem would appear to switch between the ranges. Unfortunately, this is not as easy as it sounds, since free contacts on the generator's range switch are often not available. It is, therefore, better to ensure that the display circuit operates independently from components in the existing instrument.

The solution

The usual method of making measurement instruments select the appropriate range is based on the most significant digit (or digits) on the display. If the number is too high, an overflow occurs, and a higher range is selected. If the number is too low, (for instance, nought), a lower range is selected. Obviously, if this system is used, it may take one or several measurements before the right range is found. Apart from the fact that monitoring the most significant digit is troublesome from a point of view of design (frequency meter ICs are not designed for this, so that an extensive decoder is required), the most annoying disadvantage of this method is the slow response to changes in the input signal frequency. Obviously, if you turn the frequency control on a generator, you want to see the set frequency as quickly as possible.

The present circuit uses a different approach. Essentially, it uses the input signal to determine which range is most appropriate. This is achieved by comparing the period of the input signal with three fixed *RC* times. The result of this comparison enables the right range to be selected from the available four. Actually, the comparison between the period time and the *RC* times takes place every other period of the input signal. This enables the circuit to 'know' the input frequency at practically any instant, and to use the value to set the appropriate range at the start of a measurement.



The circuit

The input signal enters the circuit via Schmitt-trigger IC1a. The use of a Schmitt-trigger gate allows sinusoidal and triangular waveforms to be measured alongside rectangular signals. As long as the input signal is greater than 1.7 V_{pp}, the Schmitt-trigger turns it into a neat rectangular wave that can be used by the frequency display without problems. The input signal is first divided by two in bistable IC3a to enable the period to be measured. The output of the bistable is alternately low and high, corresponding to the periods of the input signal. This signal is used to drive the circuit that determines the range selection. The range selection control consists of bistables IC3b, IC4a and IC4b, electronic switches IC8b-IC8d, and the *RC* networks with C2-C3-C4. If the output of IC3a is logic high, the electronic switches are closed, and the three capacitors are discharged. As soon as the output of IC3a goes low, the switches are opened, and the three capacitors are charged at different rates. Depending on the period of the input signal, none, one, two or three capacitors (C2, C3, C4) are charged until the data input of the bistable connected to each of the capacitors recognizes the voltage level as a logic 'one'. At the end of the period, when the output of IC3a reverts to high, the bistables are supplied with a clock signal that serves to record the charging level of the three capacitors. Finally, the three bistable output signals are

MAIN SPECIFICATIONS

- Four-digit LED display
- Automatic range selection
- Measurement range: 1 Hz - ≥2 MHz
- Accuracy: ±(5 ppm of readout + 1 digit)
- Drift due to ageing: ±3 ppm/ year
- Input sensitivity: 1.7 V_{pp}

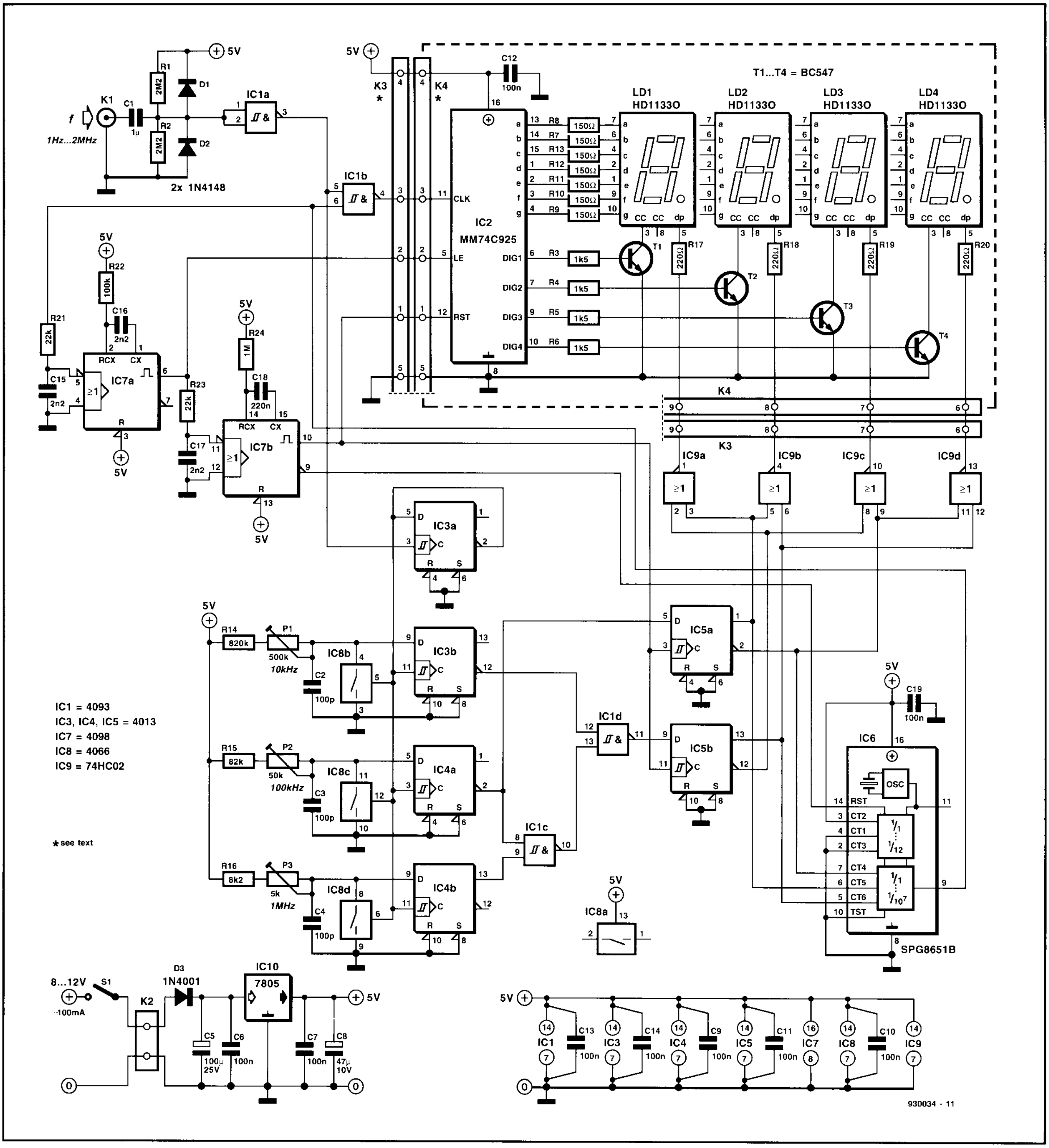


Fig. 1. Circuit diagram of the universal frequency readout.

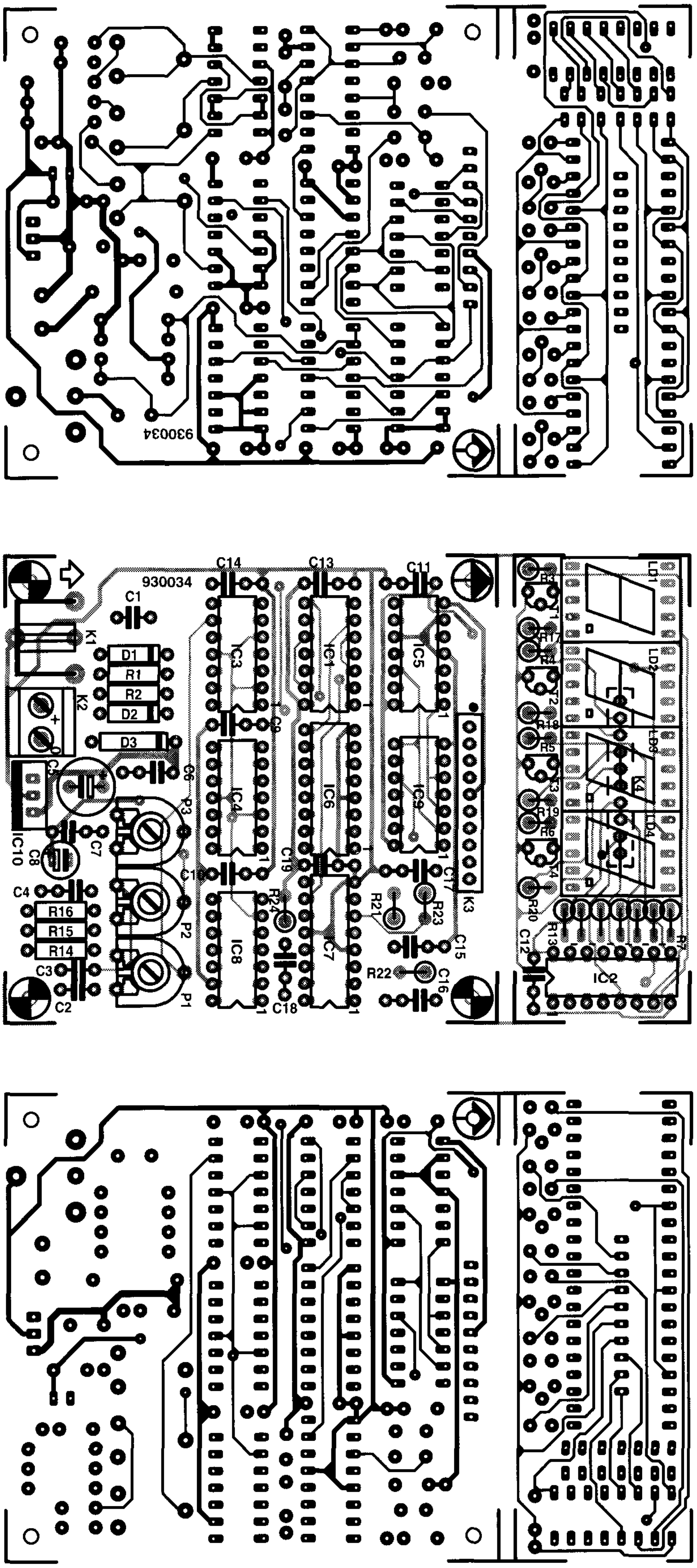


Fig. 2. The double-sided and through-plated printed circuit board consists of two sections to keep the overall size of the readout as small as possible.

COMPONENTS LIST

Resistors:

2	2MΩ2	R1;R2
4	1kΩ5	R3-R6
7	150Ω	R7-R13
1	820kΩ	R14
1	82kΩ	R15
1	8kΩ2	R16
4	220Ω	R17-R20
2	22kΩ	R21;R23
1	100kΩ	R22
1	1MΩ	R24
1	500kΩ preset H	P1
1	50kΩ preset H	P2
1	5kΩ preset H	P3

Capacitors:

1	1µF MKT	C1
3	100pF	C2;C3;C4
1	100µF 25V radial	C5
9	100nF	C6;C7;C9-C14; C19
1	47µF 10V radial	C8
3	2nF2	C15;C16;C17
1	220nF	C18

Semiconductors:

2	1N4148	D1;D2
1	1N4001	D3
4	BC547	T1-T4
1	4093	IC1
1	MM74C925 (National Semiconductor)[1]	IC2
3	4013	IC3;IC4;IC5
1	SPG8651B (Seiko-Epson)[2]	IC6
1	4098	IC7
1	4066	IC8
1	74HC02	IC9
1	7805	IC10
4	HD1133O (Siemens)[3]	LD1-LD4

Miscellaneous:

1	PCB mount cinch socket	K1
1	PCB terminal block pitch 5mm	K2
1	10-way angled PCB mount pin header plus socket	K3
1	on/off switch	S1
1	(optional) Enclosure EM10/03 (ESM)[4]	
1	Printed circuit board 930034 (see page 70)	

[1] Abacus Electronics Ltd. (0635) 33311; ESD Distribution Ltd. (0279) 626777; Farnell Electronic Components Ltd. (0532) 636311; Jermyn Distribution (0732) 740100; Makro Marketing Ltd. (0628) 604422; Thame Components Ltd. (0844) 261188; C-I Electronics (+31) 45 241877; Viewcom Electronics (081) 471 9338.

[2] Abacus Electronics Ltd. (0635) 33311.

[3] ElectroValue (0784) 442253.

[4] Maplin Electronics (0702) 554161.

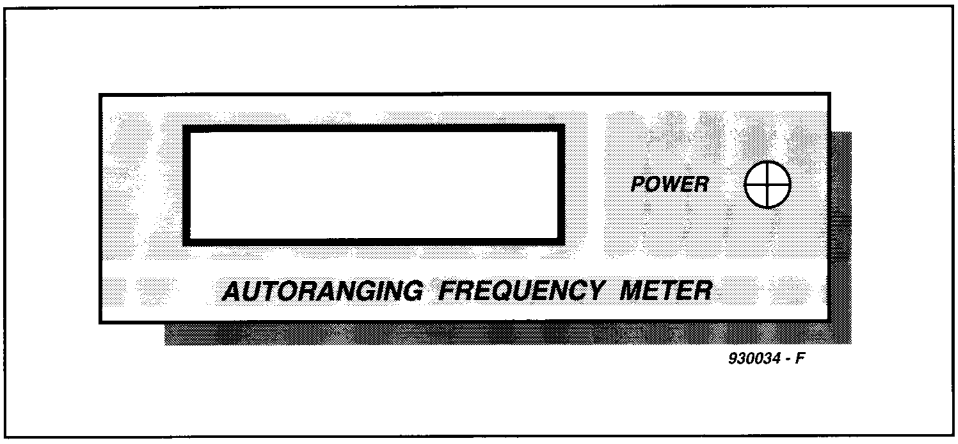


Fig. 3. Suggested front panel design.

combined, by IC1c and IC1d, into two drive signals which are used for the actual range selection.

If the measurement range of a frequency meter has to be changed, the so-called gate time supplied by the time base has to be altered accordingly. The gate time determines how long the frequency meter counts periods of the input signal and, thus, the highest frequency that can be measured. The time base is contained in a single integrated circuit, IC6, which also comprises an accurate quartz crystal oscillator and an adjustable divider. The IC used here, an SPG8651B from Seiko-Epson, was introduced along with a number of other, similar ICs, in an earlier article describing a Mini Square-wave Generator (Ref. 1).

The timebase IC is easily programmed with the aid of the two drive signals furnished by the range recognition circuit. The only proviso is that a measurement once started must not be upset any time the range recognition circuit indicates another range. This is particularly annoying with frequencies close to the range limits. To prevent problems, two bistables are inserted between the range recognition and the timebase control inputs. These bistables, IC5a and IC5b, keep the new data supplied by the range recognition latched until the frequency measurement is started again. The connection between the bistable outputs and IC6 is such that the IC supplies a gate signal of 1 ms (≥1 MHz), 10 ms (100 kHz – 1 MHz), 100 ms (10 kHz – 100 kHz) or 1 s (≤10 kHz), depending on the measurement range required. The outputs of IC5a and IC5b also control the decimal points on the LED display. The points are driven via four NOR gates, IC9a-IC9d, which ensure that the frequency is always displayed in kilohertz (kHz).

The gate time switch is formed by gate IC1b. As long as the gate is open, the input signal arrives at IC2. The MM74C925 contains a four-digit counter, a latch to store the last measurement result, and a multiplexer/display driver to put the measurement result on a readout which consists of four 7-segment LED displays. The external parts around IC2 are limited to seven current limiting resistors for the display segments, and four switching transistors for the multiplex control.

To explain the relation between the various sections of the circuit, a description follows of the events that make up a measurement cycle. The cycle starts and ends with a reset pulse supplied by monostable IC7b. This resets the counter in IC2 and the dividers in timebase IC6. At the same time, the code that represents the last used measurement range is clocked into bistables IC5a and IC5b, and fed to the timebase. After the reset pulse, the time base IC starts to work again. As soon as its output goes high, gate IC1b is enabled, and the input signal allowed to reach counter IC2. The output of IC6 goes low after the measurement time has elapsed. Gate IC1b then blocks the input signal, and IC2 stops counting. The logic low level at the timebase output is delayed briefly by R21-C15, and then used to trigger monostable IC7a. The monostable output pulse causes the state of the counter contained in IC2 to be clocked into the internal latch. After a short delay introduced by an *RC* network, R23-C17, the negative (trailing) edge of this pulse triggers IC7b, which responds by generating the reset pulse. This closes the measurement cycle.

Power supply consideration

It would be nice if the frequency display could be powered by the equipment into which it is incorporated. Although the supply voltage (if necessary, via IC10) will not be a problem in most cases, the current drain (approx. 100 mA) could be on the high side. If problems are envisaged, it is recommended to power the frequency display from a mains adaptor. This solution is both economical and safe.

The printed circuit board

The reason for keeping the printed circuit board as small as possible is obvious: the frequency display is intended for incorporating into existing equipment. Not surprisingly, the PCB is double-sided and through-plated. Furthermore, the PCB consists of two sections (display board and main board) which are mounted together at right angles. This reduces the space required for the unit considerably. Obviously, it is also possible to mount the two boards further apart, and interconnect them via a length of flatcable. For the right-angle construction, an angled PCB pinheader is mounted in position K3, and nothing in position K4. If desired, the displays are inserted into a 40-way IC socket. This raises the displays above the other parts, and allows them to be mounted flush against a front panel bezel. When all parts have been mounted on to both PCBs, the pinheader pins are inserted into the holes for K4 on the display board. This connection between the two boards is secure by virtue of the through-plated holes.

Testing

Initially, turn the wipers of the three presets fully anti-clockwise. Next, apply an input signal with a frequency of 9.5 kHz. Monitor the voltage at pin 13 of IC3, and carefully advance P1. The setting is correct when the voltage suddenly goes high. If you have the feeling that P1 is set too far, turn the wiper back, and start again. Next, do the same for P2, at an input frequency of 95 kHz, measuring the voltage at pin 1 of IC4. The last adjustment is P3: input frequency 950 kHz, voltage measured at pin 13 of IC4. That completes the adjustment, since the timebase is factory calibrated. ■

Reference:

1. Mini Square-wave Generator, *Elektor Electronics* February 1992.

MICROWAVE CONTROL PANEL. Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable). Ideal for all sorts of precision timer applications etc. **Now only £4.00 ref 4P151.** Good experimenters board.

FIBRE OPTIC CABLE. Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29R or £2 a metre.

12V SOLAR CELL. 200mA output ideal for trickle charging etc. 300 mm square. Our price £15.00 ref 15P42R. Gives up to 15v.

PASSIVE INFRA-RED MOTION SENSOR. Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual overide facility. Complete with wall brackets, bulb holders etc. Brand new and guaranteed. **Now only £19.00 ref 19P29**

Pack of two PAR38 bulbs for above unit £12.00 ref 12P43R

VIDEO SENDER UNIT. Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel). 12v DC op. £15.00 ref 15P39R Suitable mains adaptor £5.00 ref 5P191R. Turn your camcorder into a cordless camera!

FM TRANSMITTER *Housed in a standard working 13A adapter* (bug is mains driven). £26.00 ref 26P2R. Good range.

MINATURE RADIO TRANSCEIVERS. A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases and earpieces. £30.00 ref 30P12R

FM CORDLESS MICROPHONE. Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42AR.

12 BAND COMMUNICATIONS RECEIVER. 9 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead. £19 ref 19P14R. Ideal for listening all over the world.

CAR STEREO AND FM RADIO. Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. **£19.00ref 19P30**

LOW COST WALIKIE TALKIES. Pair of battery operated units with a range of about 200'. Our price £8.00 a pair ref 8P50R. Ideal for garden use or as an educational toy.

7 CHANNEL GRAPHIC EQUALIZER plus a 60 watt power amp! 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14R.

NICAD BATTERIES. Brand new top quality. 4 x AA's £4.00 ref 4P44R. 2 x C's £4.00 ref 4P73R, 4 x D's £9.00 ref 9P12R, 1 x PP3 £6.00 ref 6P35R Pack of 10 AAA,s £4.00 ref 4P92R.

TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE. The ultimate equivalents book. New ed. £20.00 ref 20P32R.

GEIGER COUNTER KIT. Complete with tube, PCB and all components to build a battery operated geiger counter. £39.00 ref 39P1R

FM BUG KIT. New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158R. 35mm square.

FM BUG Built and tested superior 9v operation £14.00 ref 14P3R

COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.

SINCLAIR C5 MOTORS. 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £22.00 ref 20P22R. Limited stocks.

ELECTRONIC SPEED CONTROL KIT .for C5 motor. PCB and all components to build a speed controller (0-95% of speed). Uses pulse width modulation. £17.00 ref *17P3R*. Potentiometer control.

SOLAR POWERED NICAD CHARGER. Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3R. 2xC cell model £6.00.

ACORN DATA RECORDER ALF503. Made for BBC computer but suitable for others. Includes mains adapter, leads and book. £15.00 ref 15P43R

VIDEO TAPES. Three hour superior quality tapes made under licence from the famous JVC company. Pack of 10 tapes **New low price £15.00 ref J15P4**

PHILIPS LASER. 2MW HELIUM NEON LASER TUBE. BRAND NEW FULL SPEC £40.00 REF 40P10R. MAINS POWER SUPPLY KIT £22.00 REF 22P33R READY BUILT AND TESTED LASER IN ONE CASE £75.00 REF 75P4R.

12 TO 220V INVERTER KIT. As supplied it will handle up to about 15w at 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17R. Larger transformer £12.00 ref 12P41R.

WIND UP SOLAR POWERED RADIO! FM/AM Radio takes rechargeable batteries. Complete with hand charger and solar *panel. £14.00 REF 14P200RA.*

BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92R, PACK OF 100 £30.00 REF 30P16R.

FRESNEL MAGNIFYING LENS. 83 x 52mm £1.00 ref BD827R.

12V 19A TRANSFORMER Ex equipment £20 but OK.

POWER SUPPLIES Made for the Spectrum plus 2 give +5 @ 2A, +12 @700mA & -12 @ 50mA. £8 ref Q8P3

UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains *operated. £6.00 ref 6P36R.*

IN CAR POWER SUPPLY. Plugs into cigar socket and gives 3,4,5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167R.

QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92R. Ideal for tea on the move!

LED PACK . 50 red, 50 green, 50 yellow all 5mm £8.00 ref 8P52

360K 5.25" DISK DRIVE. Industry standard, ideal replacement or second drive for most computers. £9.00 EACH ref: X9P1.

PPC PSU *13.8V 1.9A (not plug in). £10.00 EACH. REF: X10P1.*

MINIMUM GOODS ORDER £5.00 TRADE ORDERS FROM GOVERNMENT, SCHOOLS, UNIVERSITIES & LOCAL AUTHORITIES WELCOME ALL GOODS SUPPLIED SUBJECT TO OUR CONDITIONS OF SALE AND UNLESS OTHERWISE STATED GUARANTEED FOR 30 DAYS.

RIGHTS RESERVED TO CHANGE PRICES & SPECIFICATIONS WITHOUT PRIOR NOTICE. ORDERS SUBJECT TO STOCK. QUOTATIONS WILLINGLY GIVEN FOR QUANTITIES HIGHER THAN THOSE STATED.

THIS MONTHS SPECIAL OFFERS

SOLAR CELLS

10 WATT SOLAR CELL (3" x 1") 14.5v/700mA

Now available by mail order Coated with exceptionally efficient amorphous silicon these glass solar cells have an almost timeless lifespan and will not suffer with discolouration. There are possibly hundreds of uses for these cells, a few of which could be: for **Car Battery Charging**, for use on **Boats** or on **Caravans**, in fact anywhere a portable **12V** supply is required. Several of our overseas Mediterranean customers with homes in remote hilly sites, use these solar cells as a daytime power source to backup generators. The solar cells can be connected in series or parallel to give higher voltages or larger current capacity. **REF: EL34P1**

PRICED at only £33.95. PLUS an additional £2.00 special packaging charge on this item in addition to £3.00 PP charge.

OTHER SOLAR PANELS:

12V 200mA GLASS SOLAR PANEL.
12" x 12" in dimension **£15.00 EACH. ref: 15P42.**

.45V 700mA SOLAR CELL.
silicon plastic encapsulated. 95 x 65 x 7.5mm in dims.
£3.00 EACH. ref: 3P42.

.45V 400mA SOLAR CELL.
silicon plastic encapsulated. 75 x 45 x 7.5mm in dims.
£2.00 EACH. ref: 2P199.

.45V 100mA SOLAR CELL.
silicon plastic encapsulated. 45 x 26 x 7.5mm in dims.
£1.00 EACH. ref: BD631.

SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

BULL ELECTRICAL

250 PORTLAND ROAD HOVE SUSSEX
BN3 5QT

MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £3.00 POST PLUS VAT.

PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY

TELEPHONE ORDERS WELCOME
TEL: 0273 203500
FAX: 0273 323077

VISA

INDUCTIVE AMPS £5.00

Made for amplifying a telephone handset for the hard of hearing. However if you hold one against a piece of wire carrying a telephone conversation you can hear both sides of the conversation! It can also be used for tracing live wires in a wall or detecting cables carring mains etc. Fully cased complete with battery and fixing strap. Aprox 2.5" diameter 1" thick.

Our Price :£5.00 Our Ref :EL5P11

CTM644 COLOUR MONITOR £79.00

Refurbished monitor suitable for many home computers standard RGB input.

Our Price :£79.00 Our Ref :EL79P11

ARCHEMEDIES A3000 PSU £10.00

A compact switch mode PSU with on/off switch, selectable voltage input 110/240. NEW O/P via fly leads. GOOD STOCKS AVAILABLE.

Our Price :£10.00 Our Ref :EL10P11

ANSWERPHONES from only £18.00

Yes its true BT approved push button dialling. These are customer returned units and have two faults. We will supply you with a chip to cure one fault then you have to sort out the other problem! NON RETURNABLE.

Prices:
£18.00 each. REF: EL18P21
£60.00 PKT 4. REF: EL60P21

PORTABLE ALARM SYSTEM £17.00

'PAL' Portable Multi Beam Scanning System. Lockable Stand-alone PIR unit with removable keys (3 supplied). This unit uses a PP3 battery and when activated emits a piercing SHRILL! The unit scans the room and memorises the layout. Should this change, the alarm is triggered. There is a 60 second exit delay.

Our Price :£17.00 Our Ref :EL17P11

PIR MOVEMENT DETECTOR £15.00

Once again we have aquired stocks of this popular line and are able to offer you a very high quality and professional detector at only **£15**. Range: 20m with a 90$_{\circ}$ arc. Day and Night Mode Dims: 15cm x 9cm x 11cm. New and boxed, complete with installation guide.

Our Price :£15.00 Our Ref :EL15P21

MANY MORE SPECIAL OFFERS
IN OUR REGULAR NEWSLETTERS

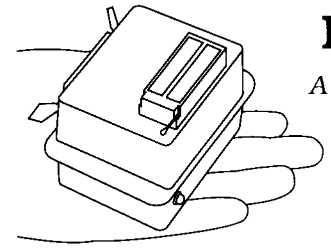
WE HAVE HUNDREDS AND HUNDREDS MORE STOCK LINES - TOO MANY TO LIST IN ONE ADVERT ! CHOOSE FROM

AERIAL AMPLIFIERS
AEROSOLS
ALARMS
AMPLIFIED SPEAKERS
ANALOGUE MULTIMETERS
APPLIANCE LEADS
BATTERIES AND HOLDERS
BATTERY CHARGERS
BOOKS
BOXES AND CASES
CAMCORDER BITS
CAPACITORS
CAR AMPS, RADIOS & SPKRS
CB SPEAKERS AND PSU's
COMPUTER BITS
CONNECTORS
DESOLDER PUMP
DIGITAL MULTIMETERS
DISCO LIGHTING
DISPLAYS
DUBBING KIT
DRILLS
FANS
FUSES
GLUE GUN AND GLUE
HEADPHONES
HEATSHRINK SLEEVING
HI FI SPEAKERS
IONISERS
LED's
LASERS AND LASER PSU's
LOGIC PROBES
LOUD AND MARINE SPKRS
MICROPHONES
PIR LIGHTS AND DETECTORS
POWERS SUPPLIES
POWER AMPLIFIERS
RADIOS
SERVICE AIDS
SOLDERING EQUIPMENT
STEAM ENGINES
TRANSEIVERS
TRANSFORMERS
WIRELESS MICROPHONES

IN SUSSEX?
CALL IN AND SEE US!!

TURN YOUR SURPLUS STOCK INTO **CASH**. IMMEDIATE SETTLEMENT. WE WILL ALSO QUOTE FOR COMPLETE FACTORY CLEARANCE.

MUCH MUCH MORE IN OUR 1993 **CATALOGUE**. PLEASE SEND 41P , A4 SIZED SAE FOR YOUR FREE COPY.



MiniProg U32

A very portable programmer for the PC

- Uses printer port (LPT1) & Mains with standard printer cables
- Program/Copy - binary file
- Comprehensive software
- Supplied in transit/storage case
- PLCC adapters available
- **Price: £169.50** + VAT

- UV Eproms from 2716 to 27040
- Flash from 28F256 to 28F020
- NVR - 8k x 8 and 32k x 8
- PCs from XT to 486 & portables

HCT Electronics
45 Apsley Way Peterborough PE3 9NY Tel: (0733) 263 127

PROGRAMMER & EMULATOR

☐ A combined eprom programmer and emulator in one case.
☐ Programs and emulates all commonly used eproms 27(C)64 to 27(C)512.
☐ A 2764 programmed and verified in 50 secs (seven different algorithms).
☐ Fast 38400 Baud serial comms, download/upload approx. 3kbytes/second.
☐ PC based software includes, basic editor, saving to disk, offset setting, directory & drive setting and controlling programming & emulation.
☐ Auto reset of target option at start of emulation.
☐ File conversion utilities and command line version included.
☐ 5v. supply only, programming voltages generated by internal SMPSU.

The PROGULATOR: £180 inc.

Further details from:

White House Systems Tel: 091-373-4605
48 South Terrace, Esh Winning, Durham DH7 9PS

WE HAVE THE WIDEST CHOICE OF USED OSCILLOSCOPES IN THE COUNTRY

TEKTRONIX 7000 SERIES OSCILLOSCOPES Dual Trace Plug-in with TB from **£200** Many Plug in options available 4 Trace Differential etc.

PLUG-INS SOLD SEPERATELY

TEKTRONICS 2445 4 Channel 150MHz Delay Sweep Cursors/Graphics	£1200
KIKUSUI COS6100M 3 Channel + Ch4, Ch5 Trig View 100Mhz Delay Sweep	£600
TEKTRONIX 475 Dual Trace 200 MHz Delay Sweep	£550
H.P. 1715A Dual Trace 200MHz Delay Sweep	£500
TEKTRONIX 465 Dual Trace 100 MHz Delay Sweep	£450
H.P. 1740A Dual Trace 100MHz Delay Sweep	£400
PHILLIPS PM3217 Dual Trace 50MHZ Delay Sweep	£400
HITACHI V650F Dual Trace 60MHz Delay Sweep	£400
TELEQUIPMENT D83 Dual Trace 50MHz Delay sweep	£200
GOULD OS3000A Dual Trace 40MHz Delay Sweep	£200
KIKUSUI 5530 Dual Trace 30MHz	£180
GOULD OS1100 Dual Trace 30MHz	£160
GOULD OS300 Dual Trace 20MHz	£200
GOULD OS250B Dual Trace 15MHz	£125

THIS IS JUST A SAMPLE - MANY OTHERS AVAILABLE

PHILLIPS PM5193 Programmable synthesizer/ Function Generator 0.1MHZ - 50MHZ IEEE-488. As new £1500

H.P. 8656A Synthesized AM/FM Sig Gen 0.1 - 990MHz	£1750
MARCONI 2022 AM/FM Sig Gen 10KHz 2GHZ	£2000
MARCONI 2019 Synthesized AM/FM Sig Gen 80KHz 1040MHz	£2000
MARCONI 2018 Synthesized AM/FM Sig Gen 80KHz 520M Hz	£950
EIP 545 Microwave Frequency Counter 10Hz 18GHz	£1400
EIP/DANA 341D Microwave Frequency Counter 20Hz 18GHz	£950
RACAL 9921 Frequency Counter 3GHz	£300
H.P. 339 Distortion Measuring Set 10Hz 110KHz	£1500
RACAL/DANA 1991Nanosecond Universal Counter	£800
RACAL 9302 RF Millivoltmeter True RMS 10KHz 1.5GHz	£450
RACAL 9301A RF Millivoltmeter True RMS 10KHz 1.5GHz	£300
RACAL 9009 Automatic Mod Meter 10MHz 1.5GHz Wide Deviation	£250
H.P. Pulse Generator type 214B	£750
LYONS PG73N Pulse Gen. PRF 1Hz 20MHz	£150
MARCONI 2610 True RMS Voltmeter	£800
KEITHLEY 224 Programmable Current Source	£1000
FARNELL PSG520 Syn. AM/FM Sig. Gen 100KHz 520MHz	£800
LEADER LSG216 AM/FM Sig. Gen 2 Ranges 0.1 30MHz & 75 115MHz	£400

SPECTRUM ANALYSERS

H.P. 141T with 8555A & IF Plug in 10MHz 18GHz	£1800
H.P. 141T with 8554B & 8552B. 500KHz 1250MHz	£1300
H.P. 140T with 8554L & 8552A 500KHz 1250MHz	£1000
H.P.141T with 8556A & 8552B 20Hz 300KHz	£1000
H.P. 140T with 85536 & 8552A 160Hz 110MHz	£800
MARCONI TF2370. 1KHz 110MHz	£1500
H.P. 182C with 8558B 100Hz 1500MHz	£1500

DATRON 1061A 6.5 digit Autocal Multimeter with True RMS AC/Current	£1250
DATRON 1065 5.5 digit Autocal Multimeter with AC/DC/Ohms with IEEE	£600
HEWLETT PACKARD 3490A Bench Multimeter 5 Digit AC/DC/Ohms	£200
PHILLIPS PM2534 Multi Function DMM 3.5 6.5 digit with GPIB/IEEE	Only £450
MARCONI Digital Frequency Meter 2430A 10Hz 80MHz	£125
MARCONI Digital Frequency Meter 2431A 10Hz 200MHz	£150
MARCONI Universal Counter Timer 2437 DC 100MHz	£175
MARCONI Universal Counter Timer 2438 DC 520MHz	£225
BLACK STAR Jupitor 500 Sine/Sq/Tri 0.1Hz 500KHz	£70
FEEDBACK FG600 Sine/Sq/Tri 0.01Hz 100KHz	£60
MULTIMETERS HAND HELD M2355 -32 ranges AC/DC 10 Amps Diode/Transistor Tester; Freq counter	£32.50

FARNELL ELECTRONIC LOAD RB1030 - 35
1KW 30Amp 35 Volt **£600**

H.P. 8690B Sweep Osc with 86974 Plug in. 26.5 40GHz	£300
RACAL /DANA RF Power Meter 9104	£400
RACAL/DANA 9341 Databridge Automatic L.C.R. & Q	£350
WAYNE KERR 8905 Automatic Precision Bridge 0.05%	£900
WAYNE KERR B605 Automatic Component Bridge 0.1%	£350

FARNELL PSU. TVS70MK2. 70V 5A, 30V 10A	£300
FARNEL PSU H60/25 0-60V; 0.25Amps Metered	£400
FARNEL PSU L30E 0.30V; 0.5Amps Metered	£80
FARNEL B30/20 0 30V. 20Amps	£250
FARNEL B20/10 0-30V. 10Amps	£200
TELEQUIPMENT CT71 Curve Tracer	£250
MARCONI TF2700 Universal LCR Bridge. Battery from	£150
AVO Valve Characteristic Meter VCM163	£300
FARNELL LA520 RF Power Amp. 1.5 520MHz 300mW	£175
RACAL 9100 Absorption Wattmeter 1MHz-1GHz 3W	£100
TRIO Wow & Flutter Meter FL190	£200
H.P. 3311A Function Gen. 0.2Hz 1MHz Sine/Sq/Tr	£125
KIKUSUI AVM23 AC Voltmeter Dual 10Hz 500MHz1	£100

FARNELL ISOLATING TRANSFORMERS
GU500 240V 500A
Un-Used £50

NEW EQUIPMENT

HAMEG OSCILLOSCOPE HM 1005 Triple Trace 100MHZ. Delay Timebase	£847
HAMEG OSCILLOSCOPE HM 604 Dual Trace 60MHZ. Delay Sweep	£653
HAMEG OSCILLOSCOPE HM203.7 Dual Trace 20MHZ. Component Tester	£362
HAMEG OSCILLOSCOPE HM205.3 Dual Trace 20MHZ. Digital Storage	£653

All other models available all oscilloscopes supplied with 2 probes

BLACK STAR EQUIPMENT (p&p all units £5)

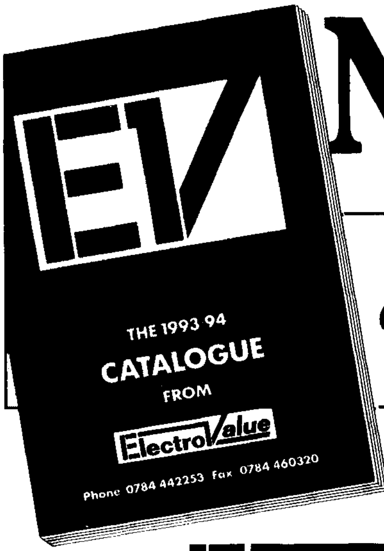
APOLLO 10 100MHZ Counter Timer Ratio/Period Time Interval etc	£222
APOLLO 100 100MHZ (As above with more functions)	£325
METEOR 100 FREQUENCY COUNTER 100MHZ	£109
METEOR 600 FREQUENCY COUNTER 600MHZ	£135
METEOR 1000 FREQUENCY COUNTER 1GHZ	£178
JUPITOR 500 FUNCTION GENERATOR 0.1 HZ 500KHZ. Sine/Sq/Tri	£110
ORION COLOUR BAR GENERATOR Pal/TV/Video	£229

All other Black Star Equipment available.

OSCILLOSCOPE PROBES Switchable x1. x10 (P&P £3)	£11

Used Equipment Guaranteed- Manuals supplied if possible
This is a VERY SMALL SAMPLE OF STOCK. SAE or Telephone for lists. Please check availability before ordering CARRIAGE all units £16
VAT to be added to Total of Goods and Carriage

STEWART of READING
110 WYKEHAM ROAD, READING, BERKS RG6 IPL
Telephone: (0734) 268041 Fax (0734) 351696 Callers Welcome 9am-5.30pm Mon-Fri (until 8pm Thurs)



READY NOW

Every keen constructor needs it

THE 1993-94
ElectroValue
CATALOGUE

DISTRIBUTORS FOR
SIEMENS
PROFESSIONAL ELECTRONIC PRODUCTS
●
SEMICONDUCTORS
●
OPTO-ELECTRONICS
●
FERRITES
CONNECTORS
SWITCHES
CAPACITORS
INDUCTORS
ETC

Profusely illustrated, this **140+** page A4 size catalogue packs a wealth of information on items from the highly sophisticated to modest but essential screws, washers and wire, etc. With **28** years in personal mail order service we know how much you rely on quality of goods above everything plus back-up service from the supplier *i.e.* **ELECTROVALUE.** We've got the catalogue you want ***and we deliver the goods!***

TO GET YOUR CATALOGUE

Send cheque or postal order for £1.50 to address on coupon or phone your Credit Card No. & its expiry date.

Catalogue comes with two £1. vouchers, each for spending with orders value £10. or more.

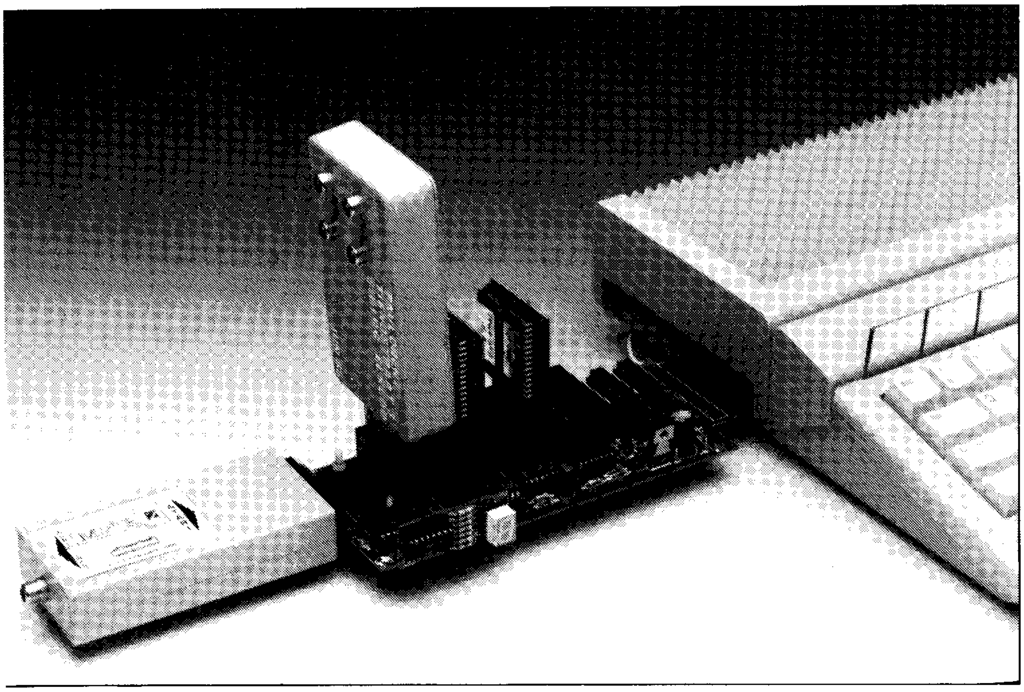
***SHOPSAT**
Egham, Surrey
28 St.Judes Road, Englefield Green.
(Tel: 0784 434757)
Burnage, Manchester
680 Burnage Lane. (Tel: 061 4324945)
**Personal Shoppers, NOT Mail Order*

ELECTROVALUE LTD, UNIT 3, CENTRAL TRADING ESTATE, STAINES. TW18 4UX
Your 1993/94 Catalogue please, to
Name ....
Address ....
....
....
Block letters please, and POST CODE
I enclose a cheque/postal order for £. .
K3

If not using coupon please quote this journal when writing

ROM GATE SWITCH-OVER FOR ATARI ST

Many games, utilities and other application software for the Atari ST computer are supplied as ROM/EPROM modules ('cartridges') of which, unfortunately, only one at a time can be connected to the computer. The circuit described here overcomes this undoubted shortcoming of an otherwise excellent computer. It allows up to five ROM/EPROM modules to be connected at the same time, and to be selected by software.



Design by E. Gilissen

THE circuit diagram of the ROM gate switch-over, **Figure 1**, is of an elegant simplicity. It can be functionally divided into four sub-circuits. Firstly, there is the connector that links the unit to the Atari's ROM port. This connector, shown in the upper left-hand corner of the diagram, consists of contact fingers etched on the printed circuit board. Two parallel connectors, K8 and K9, are provided to allow the unit to be connected to the Atari via a cable.

The second block contains the electronics proper, which includes four 8-bit bus transceivers (or bus buffers), IC1 to IC4, and two 4-to-16 line decoders/demultiplexers, IC5 and IC6. Between the bus buffers and the decoders sit a 4-bit 3-state output data latch, and five inverters contained in IC8.

The third block consists of the output connectors, K1 to K5, into which the Atari cartridges are inserted.

The fourth block contains a 7-segment LED display which is driven by a BCD-to-7-segment latch/decoder/driver, IC9. The dashes around this sub-circuit indicates that it forms a separate unit. The 7-segment LED display indicates the number of the cartridge selected by the software.

The switch-over unit and the cartridges connected to it are powered by an inexpensive mains adapter with an (unregulated) output voltage between 8 V and 15 V d.c.

To protect the host computer to which the unit is connected, all bus lines are buffered by 74HCT245 devices. Also, the switch-over unit is powered externally, for instance, by an external disk drive power supply. Since the data flow is unidirectional (from the switch-over unit to the computer only), the G3 (direction) control inputs of the databus buffers, IC1 and IC2, are normally held at a fixed positive level by resistor R2. The buffers are enabled via their G3 inputs by a low level on the $\overline{\text{ROM3}}$ or $\overline{\text{ROM4}}$ line. The OR function (for logic low levels) is provided by diodes D3 and D4.

The address bus lines are buffered by IC3 and IC4. Of the 16 buffers available in the two HCT245 devices, 15 are used for the Atari's address lines, and one for the $\overline{\text{ROM3}}$ line. Buffering of this line is essential because of the relatively high load on it.

For your reference, the pinning of the Atari cartridge (ROM port) connector is given in **Fig. 2**.

A small modification is required inside the Atari computer. Pin 2 of the ROM port connector is disconnected from the +5 V supply voltage (Vcc), and connected to the PA7 line, which can be taken from pin 14 of the sound generator IC Type AY8910. After this modification, it is no longer possible to connect cartridges to the Atari without making use of the switch-over unit. If you object to this, install a small change-over switch that allows cartridge connector pin 2 to be taken to Vcc or the PA7 line.

How it works

When the circuit is switched on, network R3-C1 resets the four-bit latch, IC7. This results in the circuit starting from 'cartridge 0'. When the PA7 line is made logic high, the output of IC8a enables the HCT173 latch via its G1 input. At the same time, IC5 is disabled by inverter IC8b. When a READ operation is performed in the address range reserved for ROM3 ($FBxxxx), the four least-significant address lines, A1 to A4, are latched on the rising (positive) edge of the $\overline{\text{ROM3}}$ signal. Because of the pull-up resistors on the databus lines, the computer reads a dummy value which consists of 'all ones', i.e., $FFFF. Next, by making PA7 logic low, each READ operation in the $\overline{\text{ROM3}}$ or $\overline{\text{ROM4}}$ address range enables one of the 74HCT154 decoders, which, in turn, translate the 4-bit latched data supplied by IC7 into a corresponding cartridge select signal. The five output signals of each 4-bit binary decoder, $\overline{\text{ROM3.0}}$ to $\overline{\text{ROM3.4}}$ (IC5),

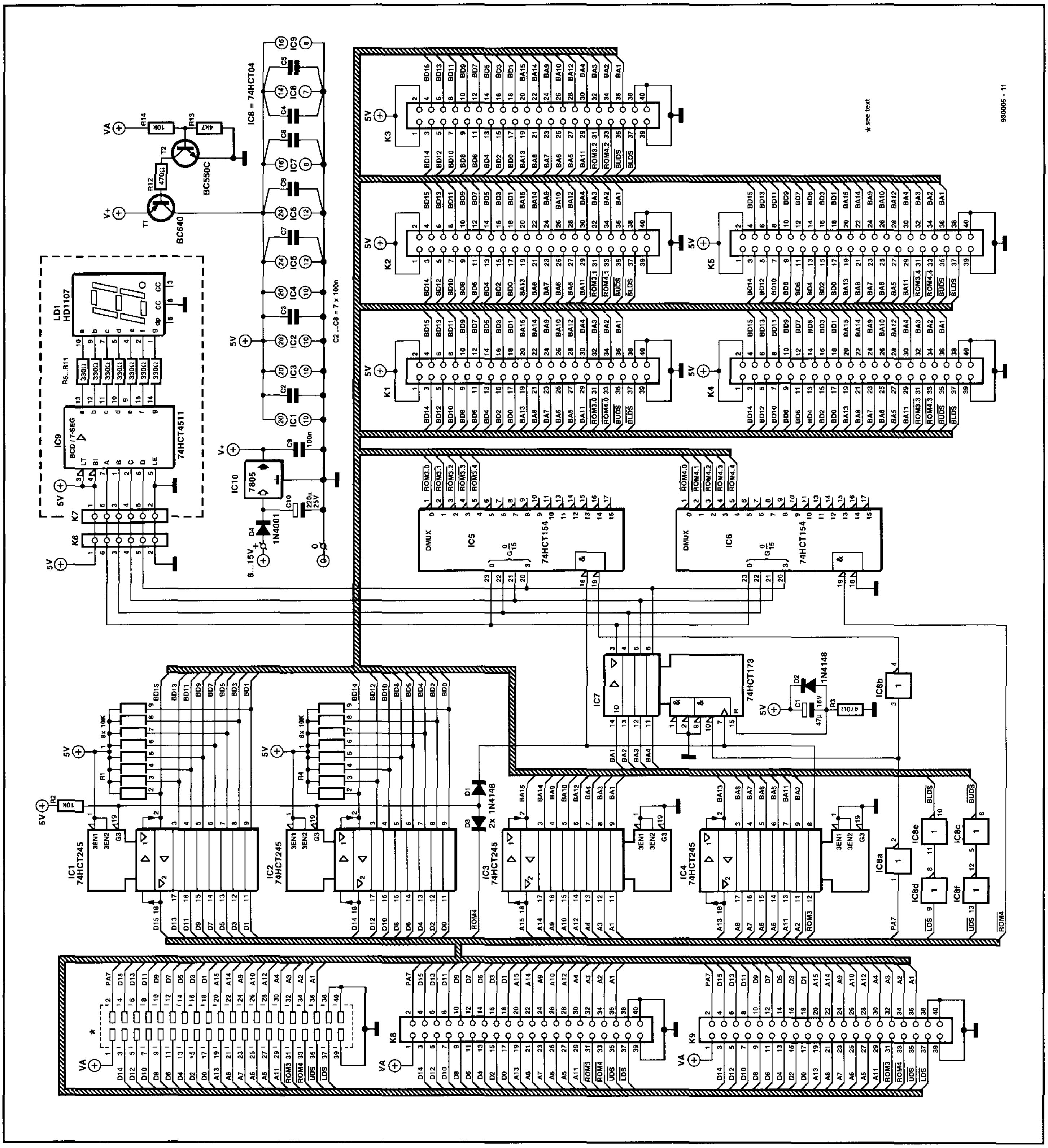


Fig. 1. Circuit diagram of the ROM switch-over for Atari ST computers.

and $\overline{\text{ROM4.0}}$ to $\overline{\text{ROM4.4}}$ (IC6), are taken in pairs to the five cartridge connectors on the board. The cartridge selection is unique, that is, only one cartridge at a time is effectively connected to the Atari host computer.

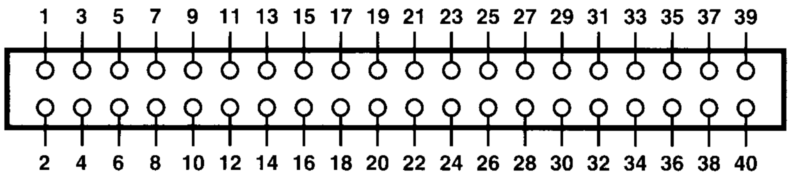
Inverters IC8d and IC8f buffer the LDS and UDS signals respectively. These signals are found back as BLDS and BUDS on each of the cartridge connectors.

The last part of the circuit to be discussed is the power-on enable switch, T_1-T_2. The function of this subcircuit is to ensure that the ICs on the switch-over unit are not powered before the Atari computer is switched on. This is achieved by making use of a switching voltage, +VA, taken from pin 1 of the cartridge connector. Likewise, the transistor switch also ensures that the ICs on the switch-over unit are cut off when the Atari is switched off. This happens despite the fact that the power supply of the switch-over unit is still on.

Construction

The printed circuit board for this project is double-sided, through plated, and, fortunately, available ready-made through our Readers Services. The artwork is given in **Fig. 4**. Because of the high density of the tracks on this board, it is not easily reproduced with hobby tools. We therefore strongly recommend buying this board ready-made.

The board consists of two sections:



1 – +5VDC
2 – +5VDC
3 – Data 14
4 – Data 15
5 – Data 12
6 – Data 13
7 – Data 10
8 – Data 11
9 – Data 8
10 – Data 9
11 – Data 6
12 – Data 7
13 – Data 4
14 – Data 5
15 – Data 2
16 – Data 3
17 – Data 0
18 – Data 1
19 – Address 13
20 – Address 15
21 – Address 8
22 – Address 14
23 – Address 7
24 – Address 9
25 – Address 6
26 – Address 10
27 – Address 5
28 – Address 12
29 – Address 11
30 – Address 4
31 – ROM Select 3
32 – Address 3
33 – ROM Select 4
34 – Address 2
35 – Upper Data Strobe
36 – Address 1
37 – Lower Data Strobe
38...40 – Ground

930005 - 12

Fig. 2. Pinning of the ROM port (also called cartridge port) connector on the Atari ST computer.

main board and display board. These are easily separated by cutting the two pieces of circuit board that hold them together. Next, the four 'humps' on the board sides are removed with a couple of strokes with a file.

Connectors K8 and K9 are optional, since they serve to connect the board to the Atari via a short length of flatcable. This is achieved by cutting the board between K8 and K9, and fitting 40-way pin headers in the connector positions. These headers are linked by a flatcable fitted with a 40-way IDC ('press-on') socket at either end. If remote connection is not required, simply leave the main board whole, and omit K8 and K9.

The first thing to do after separating the display board from the main board is to change four of the five Atari cartridge connectors from angled pin types into straight pin types. The latter are, apparently, not available. Straighten the 40 pins on each connector carefully with the aid of a pair of precision pliers. Obviously, not all five connectors need to be fitted if you never plan to fit five cartridges.

Connector K5 remains an angled pin type to allow cartridges for horizontal mounting to be used, too.

Start the construction with the display board. The LED display is best inserted into a socket made from two 5-pin sockets cut from a longer strip. The display board is mounted at right angles to the main board with the aid of an angled pin header (K6-K7) cut to a length of six pins. If you can not get hold of such a connector, six left over resistor wires, bent at 90°, will do equally well.

The construction of the main board will take a little more time. Start by fitting the small components, i.e., the diodes, resistors, resistor networks, capacitors, the voltage regulator and the transistors. Next, fit sockets for all ICs, taking good care to observe the orientation indicated by the component overlay. Finally, mount the cartridge connectors. Note that these have no PCB orientation notches.

The 3-mm holes in the main board may be used to insert plastic PCB stand-offs that serve to prevent the board from bending downward and exerting strain on the Atari's cartridge connector.

Having completed the switch-over board, you are ready to proceed with the PA7 signal, which is taken from pin 14 of the AY8910 sound generator IC. Several options are available, so read the following carefully.

Solder one end of a 40-cm long wire either directly to pin 14 of the AY8910, or to the corresponding solder island at the track side of the computer's main board. The latter option requires disassembling the computer to gain access to the solder side of the main board.

You then have two options: the PA7 connection may be made (1) via the cartridge connector, or (2) via the wire described above.

For option (1): Cut the track that leads to pin 2 of the cartridge connector in the computer. Reduce the length

In GFABASIC:

```
~XBIOS(30,128)                !enable HCT173 latch.
~PEEK(&HFB0000+(romno%*2)     !dummy read to base address
                               + (cartridge no.*2).
~XBIOS(29,127)                !disable HCT173 latch.
```

In MC68000 machine language:

Entry: D0.W = number of port to be enabled

```
asl.w      #1,d0              ;D0 * 2.
move.w     d0,-(a7)           ;save on stack
move.l     #S1E0080,-(a7)     ;parameter + no. xbios.
trap       #14                ;XBIOS.
lea        $FB0000, a0        ;base address.
move.w     4(a7),d0           ;move D0 to XBIOS again.
move.w     0(a0,d0.w),d0      ;dummy read.

move.l     #S1D007F,(a7)      ;clear previous parameters.
trap       #14                ;XBIOS.
addq.w     #6,a7              ;both .W and .L equal to An.
```

Fig. 3. Examples of cartridge selection under software control.

of the above mentioned wire as required, and solder the free end to pin 2.

For option (2): Cut the track that starts at contact finger '2' of the etched connector on the main board (contact finger '2' is at the solder side of the board). The cut is made close to the contact finger. Next, connect the free end of the wire to the track that runs close to the edge of the board.

It should be noted that option (1), the 'connector link', is preferred over the 'flying wire' alternative.

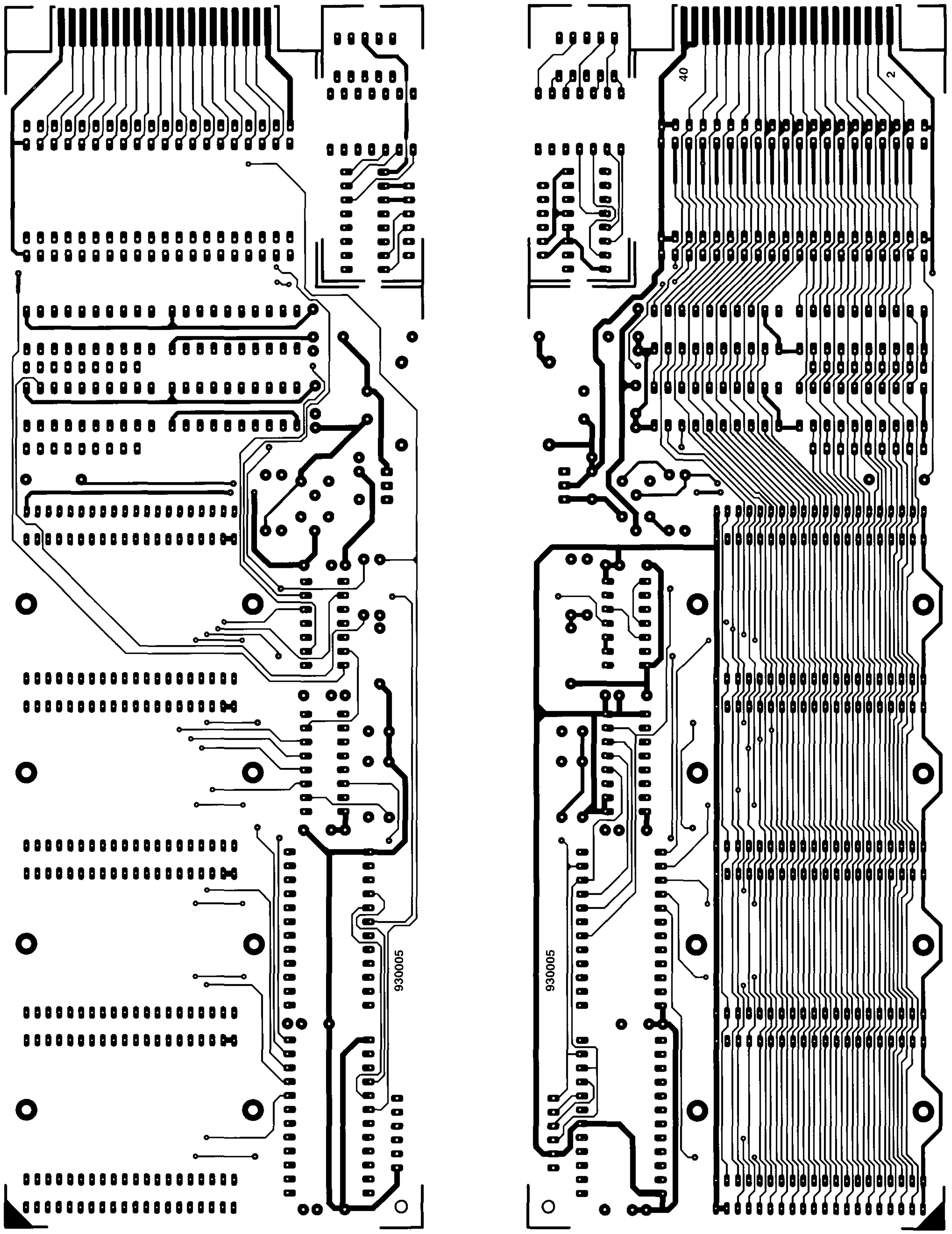


Fig. 4a. Track layouts of the double-sided PCB designed for the ROM switch-over unit.

Testing

Having checked the work so far for short-circuits, cold solder joints and incorrectly orientated parts, it is time to run a few initial tests. Switch off the Atari, and insert the ROM switchover unit into the cartridge connector at the side of the computer. Make sure the PA7 signal is fed to the switchover board — see above for the options.

Switch on the ROM switch-over unit, and then the Atari. If everything goes well, the display should indicate '0', which means that the computer has access to the cartridge inserted into connector K1. Cartridges containing 'boot-up' programs should, therefore, be inserted into K1.

If this works, switch off the Atari, and then the switch-over unit. Next, plug your cartridges on to the connectors on the board. Switch the computer and the switch-over unit on again.

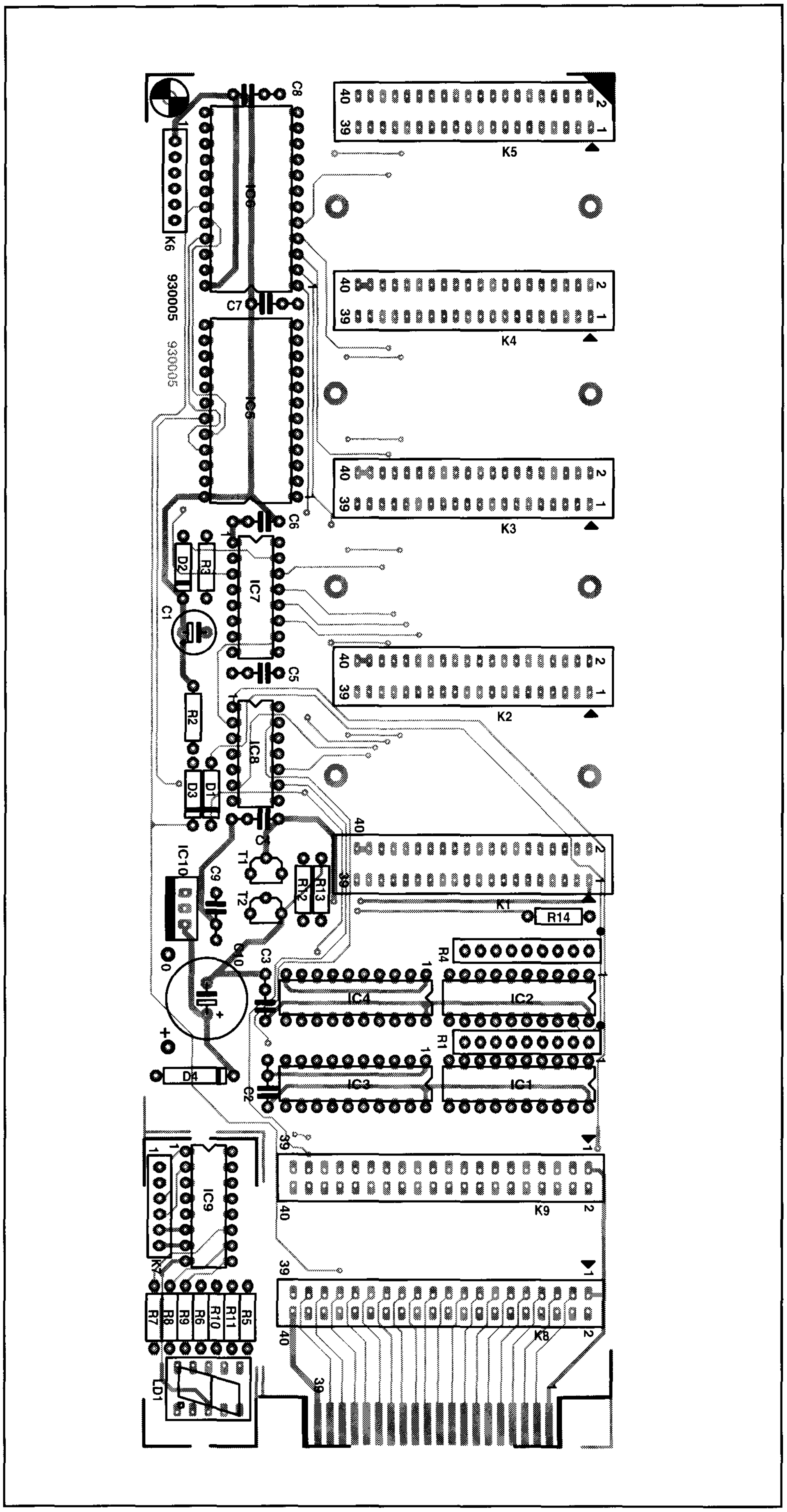


Fig. 4b. Component mounting plan.

Software

As already mentioned, the cartridge selection runs under software. Either GFA-BASIC or machine code may be used for this purpose, and **Figure 3** gives the 'bare bones' software to get you going. ■

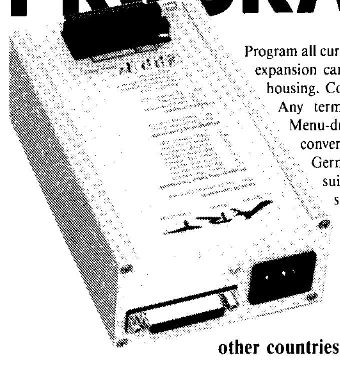
COMPONENTS LIST

Resistors:		
2	8-way 10kΩ SIL	R1;R4
2	10kΩ	R2;R14
2	470Ω	R3;R12
7	330Ω	R5-R11
1	4kΩ7	R13
Capacitors:		
1	47µF 16V radial	C1
8	100nF	C2-C9
1	220µF 25V radial	C10
Semiconductors:		
3	1N4148	D1-D3
1	1N4001	D4
1	BC640	T1
1	BC550C	T2
4	74HCT245	IC1-IC4
2	74HCT154	IC5;IC6
1	74HCT173	IC7
1	74HCT04	IC8
1	74HCT4511	IC9
1	7805	IC10
1	HD1107O (Siemens)[1]	LD1
Miscellaneous:		
5	Atari 40-way female cardedge connector	K1-K5
1	6-way SIL socket	K6
1	6-way SIL header	K7
2	40-way box header	K8,K9
1	Printed circuit board 930005 (see page 70)	

[1] ElectroValue, Unit 3, Central Trading Estate, Staines, Middlesex TW18 4UX. Telephone: (0784) 442253. Fax: (0784) 460320.

E(E)PROM PROGRAMMERS

MADE IN HOLLAND



Program all current E(E)PROMs. Built-in power supply. No extra expansion card needed. Strong compact anodized aluminium housing. Connectable to any computer with an RS232 port. Any terminal emulator through ASCII command set. Menu-driven software for IBM-compatible, FFC format converter and updatable database. Manual: English, German, French (EPP_2 also Spanish). The EPP_2 is suitable for 8 Mbit devices although detailed specifications of such devices are not yet available.

DEALERS WANTED

UK customers contact Maplin
other countries please contact European HQ Comdis

specifications	EPP_1F	EPP_2
Memory size	1 Mbit	4 Mbit (8 Mbit)
Baudrate	300 up to 19.200	300 up to 19.200
Parity	None, Odd, Even	None, Odd, Even
Handshake	None, RTS/CTS, XON/XOFF	None, RTS/CTS, XON/XOFF
Data format	Motorola s1f, s2f and s3f	Motorola s1f, s2f and s3f
Socket	ZIF-28	ZIF-32
Power	4.5 VA	8 VA
Weight	0.630 kg	0.780 kg
Voltage	115 or 230 VAC	115 or 230 VAC
Dimensions	175 x 103 x 65 mm	175 × 103 × 65 mm

PRICES:

EPP_1F: UK £123,00

EPP_2 : UK £179,00

Why build one yourself if you can buy 'ready-made' at these prices?

Prices do not include taxes. Delivery exworks.
* Payment in advance on our Bank ABN/AMRO, Eindhoven, The Netherlands, Accountnumber: 52.77.86.284. Swift Address: ABNANL 2A ABN/AMRO Amsterdam.
* VISA Card, please add 6%.
All payments must be accompanied by full name and address of customer, quantity and type of programmer. Delivery within 2 weeks upon receipt of payment.

Comdis Nederland P.O. box 4945
5604 CC Eindhoven The Netherlands
Tel.: +31 (0)40 - 12 82 17 Fax: +31 (0)40 - 12 82 71
Computer Distribution, Services & Consultancy

Build your own P.C.

Motherboards

386SX-40MHZ	£65
386DX-40MHZ 128K CACHE	£98
486SX-25MHZ 256K CACHE	£149
486SX-33MHZ 256K CACHE	£169
486DX-33MHZ 256K CACHE	£275
486DX-40MHZ 256K CACHE	£295
486DX2-50MHZ 256K CACHE	£310
486DX-50MHZ 256K CACHE	£349
486DX2-66MHZ 256K CACHE	£360
VESA VL-Bus motherboards add	£10
EISA motherboards please ring	

Add-on Cards

I/O Card 2S/1P/1G	£12
IDE Card 2HD/2FD with Cables	£12
IDE I/O Card 2HD/2FD/2S/1P/1G w cables	£16
IDE Caching Card (0k) 4HD/2FD	£135
16-bit Ethernet Card(NE2000) comp	£55
32-bit Ethernet Card EISA	£159

Display Cards

Mono Card with Printer Port	£13
Oak 16-bit VGA with 256k	£22
Oak 16-bit VGA with 512k	£28
Oak 16-bit VGA with 1MB	£38
Trident 8900cl 16 bit VGA with 1MB	£39

Floppy Disk Drives

5¼" 1.2MB Floppy Disk Drive	£35
3½" 1.44MB Floppy Disk Drive	£33
3½" 1.44MB Floppy with 5¼" Frame	£36

Hard Disk Drives

42MB IDE 14ms	£77
85MB IDE 17ms	£128
130MB IDE 16ms	£145
213MB IDE 14ms	£195
330MB IDE 12ms	£295
420MB IDE 12ms	£360
520MB IDE 12ms	£560
1GB SCSI 9ms	£750

Tape streamers

Jumbo 120MB Tape Streamer	£105
Jumbo 250MB Tape Streamer	£155

Monitors

14" SVGA Colour Monitor (0.28mm)	£175
14" Non-Interlaced Colour Monitor	£199
14" Mono VGA Monitor	£89

Cases

Deluxe Desktop Case	£55
Mini-Tower Case	£59
Tower Case	£89

Other Items

102-Key Keyboard	£22
Mouse (with Software)	£12
1MBx9 SIMM 70ns	£25
4MBx9 SIMM 70ns	£100

Please ring for a copy of our **FREE** catalogue TODAY.
prices exclude VAT & carr. Access & Visa cards welcome.

J. P. Distribution

The Old School, Prickwillow,
Ely, Cambs, CB7 4UN.
Tel / Fax (0353 88325)

SUMMER 1993 CATALOGUE

Electronic Constructors catalogue
Cirkit
£1.90
components
kits
test equipment
32 EXTRA pages!
Low Cost Security Products
Scanning Receivers covering all mobile frequencies
Summer 1993

The new enlarged Cirkit Catalogue is out now!

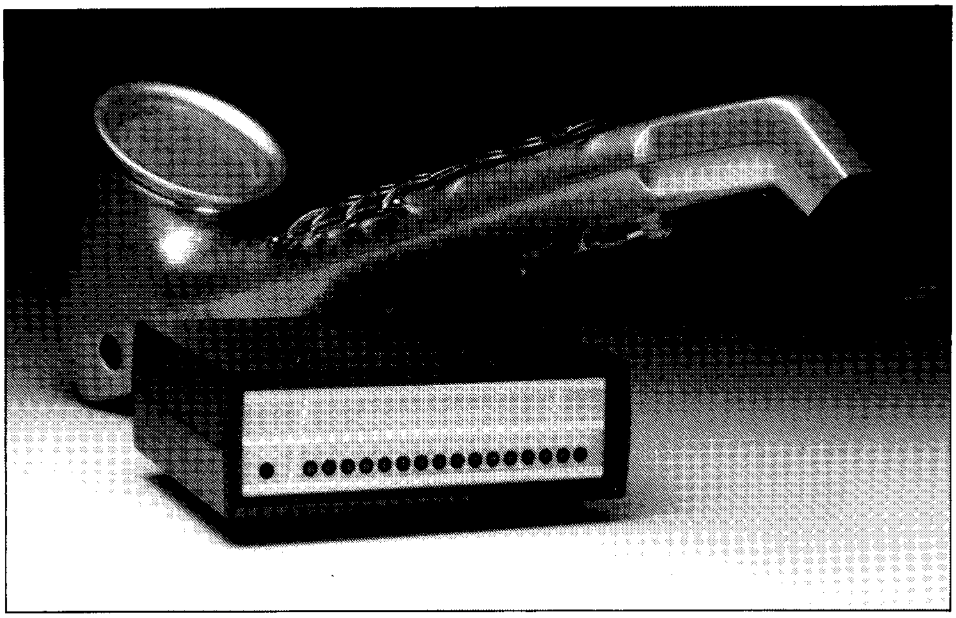
- 32 more pages
- New range of Kenwood 'scopes
- The latest scanning receivers and accessories
- New section of low cost security products
- Extended range of Velleman kits including: 250W 12Vdc to 220Vac inverter, in-car amplifier power supply, 200 and 400W amplifiers, suppressed lamp dimmer, halogen lamp dimmer, day/night thermostat and telephone remote control unit
- New test equipment, includes: 2.3GHz bench frequency counter, EPROM emulator/programmer, portable 'scopes and bench function generators
- Host of new components, including: compression trimmers, variable capacitors, connectors, fuses, and fuseholders, potentiometers, IC's, soldering irons and lead free solder
- Published 27th May 1993
- Available from most large newsagents or directly from Cirkit
- **Send for your copy today!**

£1.90 + 30p p&p

Cirkit

CIRKIT DISTRIBUTION LTD
Park Lane · Broxbourne · Hertfordshire · EN10 7NQ
Telephone (0992) 444111 · Fax (0992) 464457

MIDI CHANNEL MONITOR



Design by W. Dunczewski

Communication between electronic musical instruments and between musical instruments and a computer is made possible by MIDI (Musical Instrument Digital Interface). Moreover, many other devices, such as lights, smoke generators, and other 'tools of the trade' can be controlled by this interface. Clearly, MIDI offers the musician a host of new facilities.

Unfortunately, MIDI also has a drawback: the exchange of commands takes place via a few lengths of cable, so that the user cannot see what is happening between the various instruments. As long as everything is all right, that is no problem. When an error occurs, it is quite a job to locate where it originates. In such a situation, the present monitor is a real boon. One of a row of LEDs on its front panel shows at which specific channel each MIDI command is directed.

The MIDI channel

As will be gathered from the name MIDI, communication takes place via digital signals. In fact, the entire connection is a simple current loop in which current pulses flow. The data rate at which this happens is 32 kbit sec^{-1}. At the transmitting end, the interface is constructed around an inverting transistor with an open-collector output. At the receiving end, the interface is based on an optoisolator.

Modern electronic musical instruments are often able to generate sound via various channels; for instance, an expander or keyboard can generate sounds simultaneously via several channels. A piano sound may be generated via channel 1 and at the same time the sound of a trumpet via channel 2. In practice, it is thus possible to reach various sounds via one MIDI connection. To ensure that only the wanted sound reacts to the command, the MIDI code has an integral 4-bit address. This means that up to 16 different sounds may be controlled via one MIDI connection. The user has to couple a channel and a sound at the receiving end and connect the correct channel number to the MIDI command. It is here that the present monitor can be a great help.

Broadly speaking, there are four MIDI commands: Channel, System Exclusive, System Real Time and System Common.

Only the channel instructions are addressed directly to one sound in an instrument. This is done with an address contained in the code.

System exclusive commands contain a code that refers to the maker and they are normally used to send specific data to an apparatus. This instruction may be used to transfer a complete file from a PC to a musical instrument.

The other two type codes refer to all the equipment that is connected to the MIDI. They fulfil functions associated with the synchronization, resetting, starting and stopping the instruments.

There is no doubt that electronics, and particularly the computer, has become a mainstay of much music making. The monitor described in this article is intended primarily for musicians who work regularly with MIDI instruments and computers.

Channel commands, which contain data about key strokes and sound selection, are used most frequently.

The monitor indicates by means of 16 LEDs which address has been incorporated in a channel command. The channel instructions that are intercepted for this purpose are:

code	instruction
\$8n	note off
\$9n	note on
\$An	poly key
\$Bn	control change
\$Cn	programme change
\$Dn	channel pressure
\$En	pitch wheel

In this table, the 4-bit address code is indicated by n. The monitor examines the data flow at the MIDI connection, detects any channel commands, and extracts the channel number from the code. The associated LED will then be powered.

So as not to waste any connections, there is also a MIDI through-put.

The circuit

The signal from the interface is applied to the circuit (**Fig. 1**) and causes a train of current pulses at the output of optoisolator IC$_1$. These pulses are reconverted into a MIDI signal via buffers IC$_{2e}$ and IC$_{2f}$. In other words, K$_1$-IC$_1$-IC$_{2e}$-IC$_{2f}$-K$_2$ is the MIDI throughput already referred to.

The current pulses are applied to the remainder of the circuit via IC$_{2d}$ and IC$_{2b}$. The buffered signal is applied to the D input of IC$_5$ and to the base of T$_1$. This transistor ensures that D$_3$ will light as soon as MIDI data are applied. Circuit IC$_5$ provides the serial-to-parallel conversion of the 8-bit data. The eight outputs of this IC (pins 4–7 and 11–14) are split into two nibbles. Four bits contain the data on the type instruction; the other four (pins 11–14), give the channel number. The data contained in these latter bits are used by demultiplexer IC$_7$ to cause one of the 16 LEDs to light via a transistor. The demultiplexer accepts the four bits the instant a pulse is applied to its strobe input (pin 1). This pulse originates from a time base circuit centred on 4 MHz oscillator IC$_{2a}$, decade counter IC$_3$, binary counter IC$_4$ and a few gates. The time base is fairly complex because the measurement time is 9.5 periods. This is unavoidable because the MIDI word contains, apart from the 8 data bits, a start bit and a stop bit. Therefore, when the start bit has been detected, 9.5 periods are needed to receive all data.

The signal at pin 3 of IC$_3$ is the clock signal divided by 32, while that at pin 151 is the clock frequency divided by 2048. The signal at pin 4 has a frequency of 31.2 kHz. This frequency coincides with the baud rate

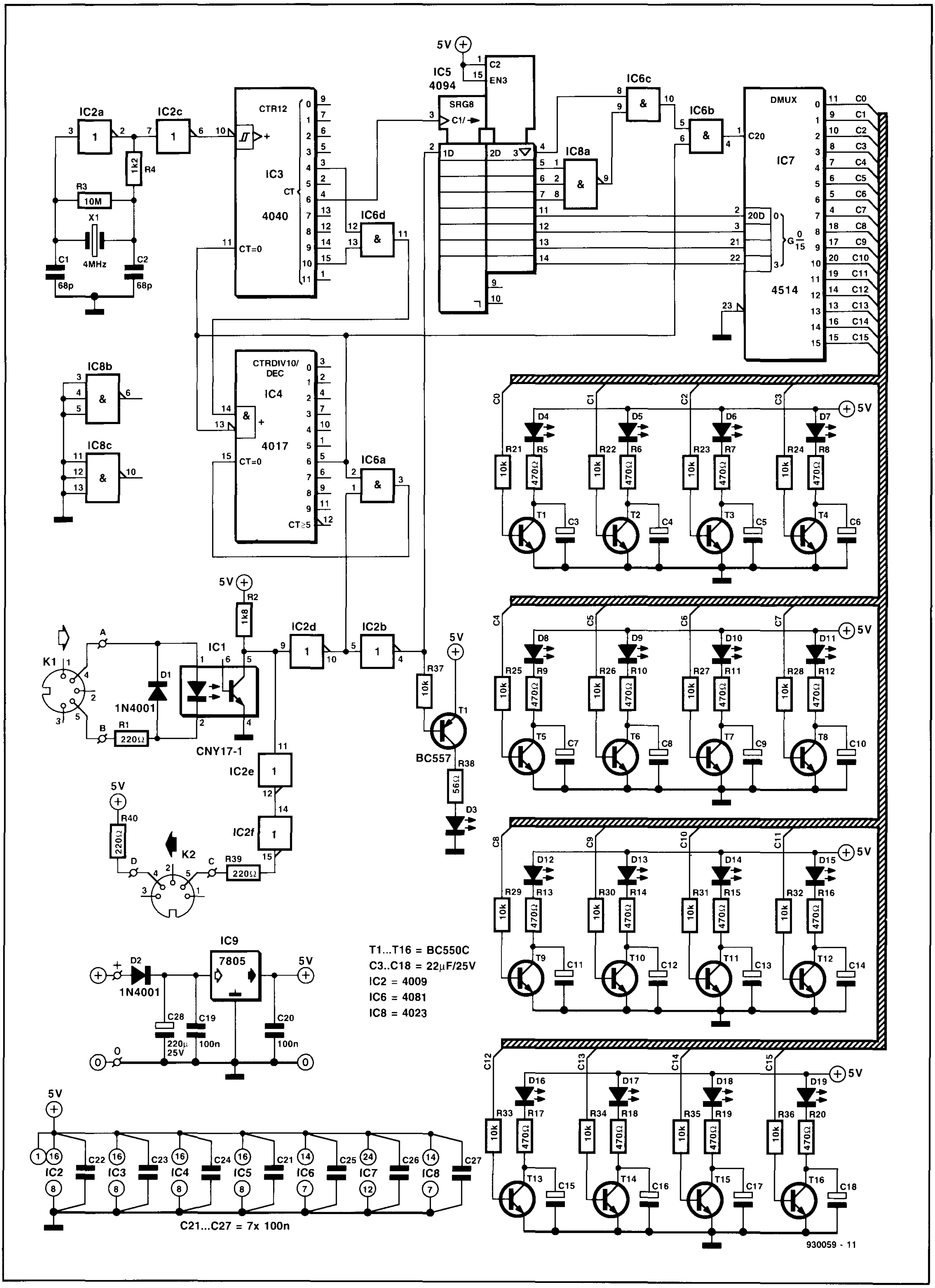


Fig. 1. Circuit diagram of the MIDI channel monitor.

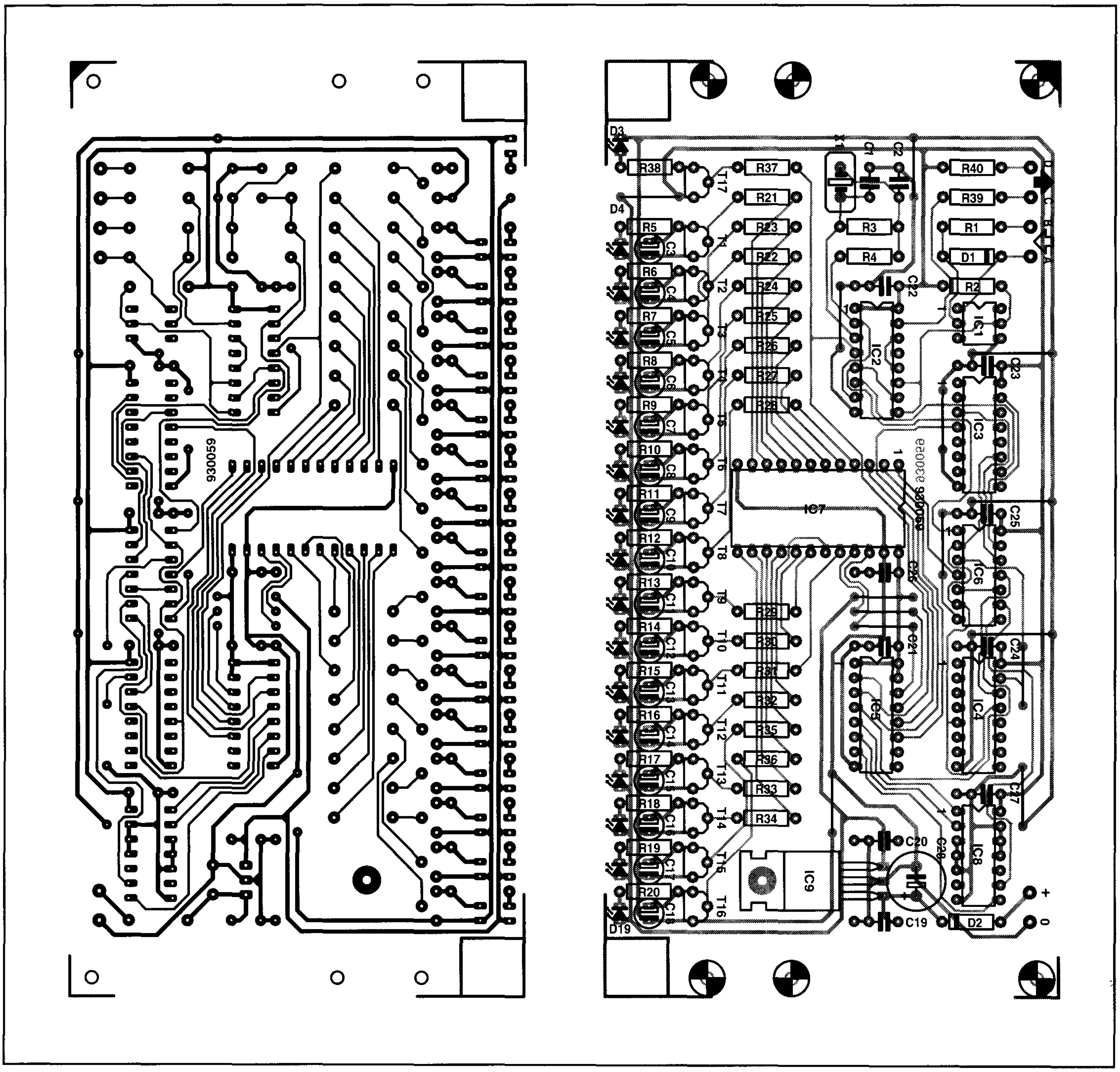
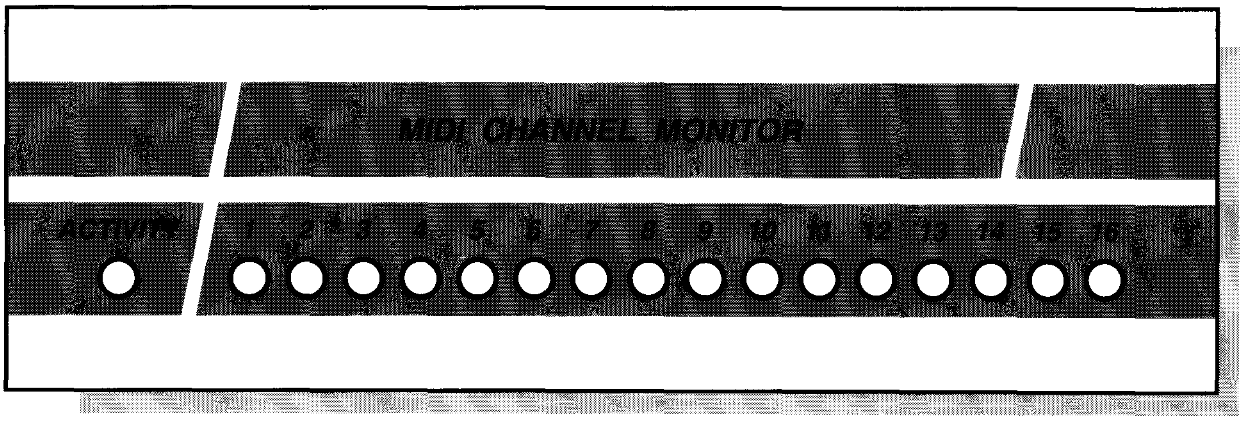


Fig. 2. Printed-circuit board for the MIDI channel monitor.



930059 - F

Fig. 3. Suggested front panel for the MIDI channel monitor.

Summary of MIDI codes

Channel
The four highest bits of a channel status byte define the command; the four lowest indicate the channel number.

9x$_H$ **Note ON event**
3 bytes 1001nnnn + 0kkk kkkk + 0vvv vvvv

nnnn
Channel code 0–15 (i.e, 16 channels available)

0kkk kkkk
Key number 0–27
For all keyboards: middle C = 60

0vvv vvvv
Key ON velocity: 0–127
If the keyboard does not contain velocity sensors, 64 is the default value

8x$_H$ **Note OFF event**
3 bytes 1000nnnn + 0kkk kkkk + 0vvv vvvv

0vvv vvvv
key off velocity

Ax$_H$ **Polyphonic key pressure**
3 bytes 1010nnn + 0kkk kkkk + 0vvv vvvv

0vvv vvvv
Pressure/after-touch value: 0–127
The code is used in the omni mode

Bx$_H$ **Control change**
3 bytes 1011nnnn + 0ccc cccc + 0vvv vvvv

0ccc cccc
Control address: 0–127
Apart from the pitche bender (0), these addresses are not specified

Cx$_H$ **Programme change**
2 bytes 1100nnnn + 0ppp pppp

0ppp pppp
Programme number: 0–127

Dx$_H$ **Channel pressure**
2 bytes 1101nnnn + 0vvv vvvv

0vvv vvvv
Channel pressure/after-touch: 0–127
In mono mode: read key instead of channel

Ex$_H$ **Pitch wheel change**
3 bytes 1110nnnn + 0kkk kkkk + 0vvv vvvv

System exclusive
This command, defined to transmit exclusive instructions, comprises a header of 2 bytes, data bytes and a terminating code of 1 byte.

Format: F0$_H$ + 0iii iiii + data + F7$_H$

F0$_H$
This status byte mustbe followed by an identification code

0iii iiii
Identification code of manufacturer, any value between 0 and 127; some values are Sequential Systems 01$_H$; Kawai 40$_H$; Roland 41$_H$; Korg 42$_H$; Yamaha 43$_H$

data
Any block of data bytes with a value of 0–127 intended for all channels

F7$_H$
This END-OF-BLOCK code terminates the command (which may also be done with a SYSTEM RESET)

System real time
This command enables direct control of the system. Applications are synchronization and rhythm system. System real time commands are transmitted on all channels. Instruments that do not know these commands ignore them.

F8$_H$ **Timing clock in play**
This clock is sent with the transmitter in play mode. The system is synchronized and has a frequency of 24 clock pulses per crotchet (USA: quarter-note)

F9$_H$ **Measure end**
The MEASURE END is sent in place of the TIMING CLOCK IN PLAY at the end of each measure.

FA$_H$ **Start from 1st measure**
This code is sent directly the PLAY key of the master (sequencer or rhythm unit) is pressed. The first TIMING CLOCK IN PLAY must be sent within 5 ms after this command.

FB$_H$ **Continue start**
This code is sent when the CONTINUE knob on the master is used. A sequence is repeated from the point where the latest TIMING CLOCK IN PLAY was received. The next TIMING CLOCK IN PLAY must be sent within 5 ms.

FC$_H$ **Timing clock in end**
This clock is generated when the master is in the wait mode; it is used to lock a PLL (phase-locked loop) in the interval when the PLL must provide the timing.

FE$_H$ **Active sensing**

System common
These data are intended for all instruments on all channels.

F1$_H$ **Undefined**

F2$_H$ **Measure information**
3 bytes F2$_H$ + 0mmm mmmm (MSB) + 0mmm mmmm (LSB)
The two data bytes code the number of the measure in a14-bit code.

F3$_H$ **Song select**
2 bytes F3$_H$ + 0sss ssss
This 7-bit code contains the song number (0–127)

F4$_H$ **Undefined**

F5$_H$ **Undefined**

F6$_H$ **Tune request**
Initializes the voice routines of the synthesizer.

System reset
This command enables the entire system to be reset.

FF$_H$ **SYSTEM RESET**

of the MIDI signal. This signal is, therefore, used to clock IC_5. The leading edge of the signal coincides with the centre of the MIDI word and is used to sample the data.

The frequency of the signal at pin 15 is $^1/_{16}$ of that at pin 4. This means that pin 15 goes high after pin 4 has output 8 pulses. The remaining $1^1/_2$ period is obtained by adding 6 pulses from pin 3 to the half-period at pin 15.

The entire operation is summarized in the timing diagram in **Fig. 5**.

As soon as pins 3 and 15 are high, the output of IC_{6d} also goes high and is used to clock IC_4. At the sixth clock pulse after the reset input has been enabled, pin 5 of IC_4 goes high. At the next leading edge in the MIDI signal, the output of IC_{6a} goes high. Depending on the level at the output of decoder IC_{8a}-IC_{6c}, the clock pulse is passed to IC_7. In practice, this means that when the high nibble of the input MIDI code is \$8, \$9, \$A, \$B, \$C, \$D or \$E, the clock pulse is passed to IC_7. All MIDI codes containing an address have then been decoded.

After pin 5 of IC_4 has become logic high, the enable input of this counter is blocked and IC_3 is reset. Circuit IC_4 is reset when the output of IC_{2d} goes high, whereupon a fresh measurement period starts.

As soon as the 4-bit channel code has been stored in IC_7, the output associated with that code will go high. The transistor connected to that output is switched on and the associated LED lights. Since the data often are of very short duration, electrolytic capacitors shunt the transistors. These ensure that the LEDs are quenched slowly to show more clearly which channel was accessed. If the time the LED lights is considered too short, the value of the capacitor may be enlarged up to 220 µF.

The power supply, derived from a mains adaptor (7.5–20 V) is straightforward: D_2 protects against reverse polarity and IC_9 holds the supply voltage at 5 V.

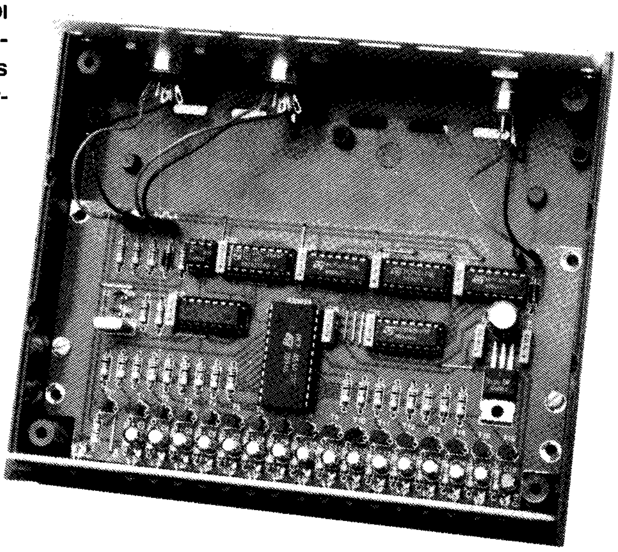


Fig. 4. This inside view of the MIDI channel monitor shows the layout of the board and the various connectors as well as the interwiring.

Construction

The monitor is best built on the printed-circuit board in **Fig. 2**. First connect the wire bridges, followed by the passive components. After the LEDs have been soldered into place, bend them at right angles so that they can protrude nicely through the holes in the front panel. It is, of course, good practice to ensure that the height of all LEDs above the board is the same.

Normally, IC_9 does not need to be cooled and can be mounted directly on to the board. After the other ICs have also been soldered into place, fit the board in a suitable enclosure. **Figure 4** shows the construction of the prototype.

After the board has been fitted into the enclosure, wire up the two DIN connectors as shown in **Fig. 1**.

Finally, mount two terminals at the rear of the enclosure for the input from the mains adaptor. Connect these internally to the supply pins on the board (0 and +) and externally to the mains adaptor.

Link the monitor into a MIDI connection, connect the mains adaptor to the mains, and press one of the keys of the muscial instrument. If everything is all right, one of the 16 LEDs will light to show via which channel the communication took place.

END

PARTS LIST

Resistors:
R_1, R_{39}, R_{40} = 220 Ω
R_2 = 1.8 kΩ
R_3 = 10 MΩ
R_4 = 1.2 kΩ
R_5–R_{20} = 470 Ω
R_{21}–R_{37} = 10 kΩ
R_{38} = 56 Ω

Capacitors:
C_1, C_2 = 68 pF
C_3–C_{18}, C_{28} = 22 µF, 25 V, radial
C_{19}–C_{27} = 100 nF

Semiconductors:
D_1, D_2 = 1N4001
D_3 = LED, red, high efficiency
D_4–D_{19} = LED, green
T_1–T_{16} = BC550C
T_{17} = BC557

Integrated circuits:
IC_1 = CNY17-1
IC_2 = 4009
IC_3 = 4040
IC_4 = 4017
IC_5 = 4094
IC_6 = 4081
IC_7 = 4514
IC_8 = 4023
IC_9 = 7805

Miscellaneous:
K_1, K_2 = 5-way DIN connector for board mounting
X_1 = crystal, 4 MHz
Enclosure as required
PCB No.930059 (see page 70)

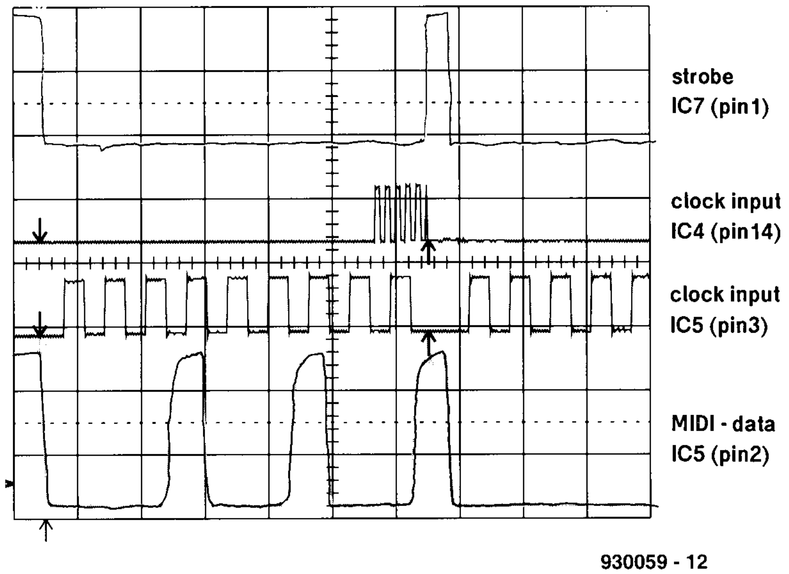


Fig. 5. Timing diagram of the MIDI channel monitor.

To be published in November 1993

305 Circuits demonstrates the practical aspects of electronics through projects that can be built at home, in a small workshop, or in the physics or science department of schools and colleges. There are projects for everyone, covering Audio & Hi-fi; Computers & Microprocessors; Music and Electrophonics; Radio, Television and Communications; and Test and Measurement.
ISBN 0 905705 36 X **Price £14·95***

SMT Projects by Owen Bishop. This book describes the special features of Surface Mount Technology and how to work with Surface Mount Devices on the workbench. It includes over 20 constructional projects, all of which have many useful applications in and around the home and workshop. The projects are selected and designed to take advantage of the distinctive features of SMT. They introduce the beginner to SMT in a practical 'hands-on' way without requiring expensive special equipment.
The book is for those who want to know more about surface mount devices and to gain practical experience of handling them.
ISBN 0 905705 35 1 **Price £9·95***

*Prices for orders received at our Dorchester office before 15 November 1993 are: *305 Circuits* £12·95; *SMT Projects* £8·25.

Orders other than from private customers, for instance, bookshops, schools, colleges, should be sent to:
Gazelle Book Services Ltd, Falcon House, Queen Square, Lancaster LA1 1RN, England.

Elektor Electronics (Publishing), PO Box 1414, Dorchester, Dorset, England DT2 8YH.

PC Based Industrial and Lab, Data Acquisition, Control and Measurement, Instrument Cards

AD/DA Cards
Plus Accessories & Software
C.P.U. Boards
Device Programmers
Digital I/O Cards
I EEE 488 Cards
Industrial Chassis
Industrial Control Cards

Interface Converters
Relay Output Cards
RS 232 Cards
Single, 2, 4, 8, 16 Port
RS 422 Cards
Single, 2, 4, 8, Port
PC ROM Disk Cards
Slot Extender Cards

Specialist PC & Multimedia Add-on Cards

PC - Telecommunication Cards
Fax Modem Cards
Voice Recognition Cards
Voice Digitiser Cards
Video/TV - PC - Video/TV Cards
Sound Cards

VISA ACCESS

Components

Cases
Floppy Disk Drives
Hard Disk Drives
From 40MB to 2.1GB
Keyboards

Monitors
Mother Boards
Cache Controller Cards
Network Cards
Tape Back Up Units

For further information, Product/Price List
Call Us On:
Tel: 0902 20267 Fax: 0902 28439
Roline Systems Ltd, Imex House,
Imex Business Park, Upper Villiers Street,
Wolverhampton, West Midlands. WV2 4NU

SWITCHBOARD

Switchboard allows all PRIVATE READERS of *Elektor Electronics* one FREE advertisement of up to 108 characters, including spaces, commas, numerals, etc., per month.

Write the advertisement, which MUST relate to electronics, in the coupon on this page; it MUST INCLUDE a private telephone number or name and address; post office boxes are NOT acceptable.

Elektor Electronics (Publishing) can not accept responsibility for any correspondence or transaction as a result of a free advertisement or of any inaccuracy in the text of such an advertisement.

Advertisements will be placed in the order in which they are received.

Elektor Electronics (Publishing) reserve the right to refuse advertisements without giving reasons or without returning them.

WANTED. Metal detector parts and/or info.from *Elektor Electronics* Nov 1981. Project sold by Crestway Electronics. Please write to Mr J. Reece, 12 Railway Cottages, Station Road, Whitstable, Kent CT5 1JZ.

FOR SALE. Eddystone receivers 880 MkII £25. S64D £90. 770R £100, S940 £190. EA12 £150. EC10, others, HRO. Phone Alan on (0344) 27869.

WANTED. Copy or buy manual for Tektronix 465 oscilloscope. Please write to C. Harding, 16 Crystal Way, Waterlooville, Hants PO7 8NB.

WANTED. Circuit diagram for I/O port for Sinclair Spectrum 48K. Will pay. Phone Mark on (0664) 60764.

FOR SALE. Ultiboard and Ulticap evaluation pack. Two months old. Fully boxed with manuals, etc. £249. Phone Martin on (0642) 321 290.

WANTED. Data books, information sheets, etc. Will pay. Phone Robin on (0268) 524 968.

FOR SALE. Sony SLC30 Beta video recorder with 31 LP and 2 cleaning cassettes. £90. Buyer collects (from Gravesend, Kent). Phone (0474) 334 997.

WANTED. *Elektor Electronics* magazine issues 1, 2, 3, 4, 5, 6, 7, 9, 12, 13, 14. Good price for clean copies. Call Steve on (0462) 454 958.

FOR SALE. *Elektor Electronics* 1983–1993. Databse disk (DB3) and programs £47.95. Phone Garyu on 081 861 2210.

FOR SALE. 1 Mbx1 80 ns DRAMs, Panasonic M4 1C1000-08 or similar. £1.00 each or offers. Phone (0933) 650 883 (evenings).

WANTED. *Elektor Electronics* 1986, 1987, 1988, 1989. Please write to Elektorcal, P.O. Box 41096, Tel Aviv 61410, Israel.

NEEDED. Satellite receiving system and financial aid for peace organization (registered under no. 75622822). Please write to Peace Organization, Dr Lahgon's Compound, Nirmal Kumar Jain's Home, Sehore (M.P.) India 466 001.

Send this coupon to
Elektor Electronics (Publishing)
P.O. Box 1414
Dorchester DT2 8YH
England

Block capitals please – one character to each box

ELEKTOR ELECTRONICS 10/93

Name and address MUST be given

READERS SERVICES

Except in the USA and Canada, all orders, except for subscriptions and past issues (for which see below), must be sent BY POST to our Dorchester office using the appropriate form opposite. Please note that we can not deal with PERSONAL CALLERS, as no stock is carried at the editorial and administrative office.

Readers in the USA and Canada should send orders, except for subscriptions (for which see below), to Old Colony Sound Lab, Peterborough, whose full address is given on the order form opposite. All US$ prices are postpaid to customers in the fifty states except for books. Please add $2.00 for the first book and 75¢ for each additional book ordered. Canadians please add US$4.50 for the first book, and 75¢ for each additional one. Canadians may expect Canadian duty charges on shipments of any items except books.

All other customers must add postage and packing charges for orders up to £25.00 as follows: UK and Eire £1.95; surface mail outside UK £2.45; Europe (airmail) £2.95; outside Europe (airmail) £3.70. For orders over £25.00, but not exceeding £100.00, these p&p charges should be doubled. For orders over £100.00 in value, p&p charges will be advised.

SUBSCRIPTIONS & PAST ISSUES

Subscriptions and past issues, if available, should be ordered from **Worldwide Subscription Service Ltd, Unit 4, Gibbs Reed Farm, Pashley Road, TICEHURST TN5 7HE, England**. For subscriptions, use the order form on the opposite page. Prices of past issues (except July/August and December), including postage for single copies, are £2.70 (UK and Eire); £3.00 (surface mail outside UK); £3.20 (air mail Europe); £3.95 (airmail outside Europe). Prices of past July/August and December issues, including postage for single copies, are £3.75 (UK); £4.00 (surface mail outside UK); £4.25 (airmail Europe); and £5.00 (airmail outside Europe).

PAST ARTICLES

Photocopies of articles from January 1978 onwards can be provided, postage paid, at £1.95 (UK and Eire), £2.10 (surface mail outside UK), £2.45 (airmail Europe), or £2.70 (airmail outside Europe). In case an article is split into instalments, these prices are applicable **per instalment**. Photocopies may be ordered from our editorial and administrative offices.

COMPONENTS

Components for projects appearing in *Elektor Electronics* are usually available from appropriate advertisers in this magazine. If difficulties in the supply of components are envisaged, a source will normally be advised in the article. It should be noted that the source(s) given is (are) not exclusive — other suppliers may also be able to help.

BOOKS

For book availability, see advertisement on page 7.

SHELF BOX

Elektor Electronics shelf box ....£2.95............$6.00

FRONT PANELS

PROJECT	No.	Price (£)	Price (US$)
Timecode interface	910055-F	8.80	17.60
Digital function generator	910077-F	10.60	21.20
4-Megabyte printer buffer	910110-F	11.45	22.90
Economy PSU	910111-F	10.60	21.20
CD Player	910146-F	12.05	24.10
Measurement amplifier	910144-F	8.80	17.60
FM tuner	920005-F	13.20	26.40
4MB printer buffer card	920009-F	8.25	16.50
LC meter	920012-F	11.45	22.90
Guitar tuner	920033-F	8.80	17.60
NICAM decoder	920035-F	8.25	16.50
12VDC to 240VAC inverter	920038-F	16.15	32.30
Audio DAC	920063-F	10.00	20.00
Dig. audio/visual system	920022-F1	10.00	20.00
	920022-F2	19.40	38.80
	920022-F3	28.80	57.60
1.2 GHz multifunction frequency meter	920095-F	13.80	27.60
U2400B NiCd battery charger	920098-F	8.75	17.50
Workbench PSU	930033-F	17.00	34.00
Inexpensive phase meter	930046-F	17.25	34.50
MIDI channel monitor	930059	Not available	
Ah meter w. digital readout	930068	Not available	
Autoranging frequency readout	930034	Not available	

EPROMS / PALS / MICROCONTROLLERS

PROJECT	No.	Price (£)	Price (US$)
Multifunction measurement card for PCs (1 × PAL16L8)	561	10.30	20.60
Video mixer (1 × 2764)	5861	11.75	23.50
RDS decoder (1 × 2764)	5951	15.30	30.60
MIDI programme changer (1 × 2764)	5961	15.30	30.60
Logic analyser (IBM interface) (1 × PAL 16L8)	5971	8.25	16.50
MIDI-to-CV interface	5981	15.30	30.60
Multifunction I/O for PCs (1 × PAL 16L8)	5991	8.25	16.50
Amiga mouse/joystick switch (1 × GAL 16V8)	6001	8.25	16.50
Stepper motor board - 1 (1 × PAL 16L8)	6011	8.25	16.50
4-Megabyte printer buffer (1 × 2764)	6041	15.30	30.60
8751 emulator incl. system disk (MSDOS)	6051	29.40	58.80
Connect 4 (1 × 27C64)	6081	15.30	30.60
EMON51 (8051 assembler course) (1 × 27256 +disk 1661)	6061	20.00	40.00
EMON51 (8051 assembler course) (1 × 27256 +disk 1681)	6091	20.00	40.00
Multi-purpose Z80 card: FM tuner (1 × 27C256)	6101	20.00	40.00
Multi-purpose Z80 card: GAL set (2 × GAL 16V8)	6111	11.15	22.30
Multi-purpose Z80 card: BIOS (1 × EPROM 27128)	6121	15.30	30.60
1.2 GHz multifunction frequency meter(1 × 27C256)	6141	11.45	22.90
Digital audio/visual system (1 × 27C256)	6171	10.30	20.60
TV test pattern generator (1 × 27256)	6151	13.00	26.00
DiAV system. Package: 1 × 27512; 2 × GAL; 1 × floppy disk (MSDOS)	6181	30.50	61.00
PAL test pattern generator (1 × GAL 20V8-25)	6211	9.40	18.60
Watt-hour meter (1 × 27256)	6241	10.00	20.00
Four fold DAC (1 × GAL)	6251	10.75	21.50
Multipurpose display decoder (1 × 2764)	6261	11.50	23.00
8751 programmer (1 × 8751)	7061	46.40	92.80
Microcontroller NiCd charger (1 × ST62E15)	**7071**	**10.00**	**20.00**
Maxi micro clock (clock)	7081	11.50	23.00
Maxi micro clock (darkroom timer)	7091	11.50	23.00
Maxi micro clock (cooking timer)	7101	11.50	23.00
Mini micro clock (clock)	7111	11.50	23.00
Mini micro clock (darkroom timer)	7121	11.50	23.00
Mini micro clock (cooking timer)	7131	11.50	23.00

DISKETTES

PROJECT	No.	Price (£)	Price (US$)
Multifunction measurement card (MMC) for PCs	1461	7.65	15.30
8751 programmer	1471	7.65	15.30
PT100 thermometer	1481	7.65	15.30
Logic analyser: IBM software on disk, incl. GAL	1491	19.40	38.80
Logic analyser: Atari software on disk (3.5"), incl. GAL	1501	19.40	38.80
Plotter driver (D. Sijtsma)	1541	11.15	22.30
I/O interface for Atari	1571	7.65	15.30
Tek/Intel file converter	1581	7.65	15.30
B/W video digitizer	1591	11.15	22.30
Timecode interface	1611	7.65	15.30
RTC for Atari ST	1621	7.65	15.30
24-bit colour extension for video digitizer	1631	11.15	22.30
PC controlled weather station - 3 (supersedes disks 1551 and 1561)	1641	7.65	15.30
8051/8032 Assembler course (IBM version)	1661	7.65	15.30
8051/8032 Assembler course (Atari version) (3.5")	1681	7.65	15.30
AD232 converter	1691	7.65	15.30
GAL programmer (3 disks; upgrade: June 1993)	1701	11.15	22.30
Multi-purpose Z80 card	1711	7.65	15.30
EPROM emulator II	129	6.75	13.50
Fuzzy Control One	**1721**	**7.75**	**15.50**
Pascal library for MMC	1751	9.70	19.40
Speech/sound memory	1771	7.65	15.30
PC-aided transistor tester	1781	7.50	15.00
IR receiver and DTMF decoder for 80C32 SBC	1791	9.00	18.00
I²C opto/relay card	1821	7.65	15.30
Video digitizer for PCs	1831	14.50	29.00
GAL programmer for Amiga	1841	11.00	22.00
I²C alphanumerical display	1851	8.50	17.00
Philips preamplifier	1861	8.50	17.00
GAL programmer (excl. Opal Jr. disks)	1881	10.75	21.50
X2404-to-8751 interfacing	1891	8.50	17.00

PRINTED CIRCUIT BOARDS

Printed circuit boards whose number is followed by a ✛ sign are only available in combination with the associated software item, and can **not** be supplied separately. The indicated price includes the software.

PROJECT	No.	Price (£)	Price (US$)
MAY 1993			
FM stereo signal generator	920155	23.00	46.00
VHF/UHF receiver	926001	19.00	38.00
Philips preamplifier	930003	7.50	15.00
Workbench PSU	930033	21.50	43.00
	920075-1	4.70	9.40
JUNE 1993			
Spectrum VU meter	920151	13.00	26.00
GAL programmer upgrade	930060	4.50	9.00
Digital frequency readout for VHF/UHF receiver	926001-2	11.50	23.00
Inexpensive phase meter			
- main board	930046	9.00	18.00
- meter board	920018	4.75	9.50
JULY/AUGUST 1993			
Active 3-way loudspeaker system	930016	21.50	43.00
Maxi micro clock	930020	15.50	31.00
Four-fold DAC for PCs	930040	Kolter Electronic	
SMD soldering station	930065	9.50	19.00
VHF-low converter	926087	15.50	31.00
I²C bus fuse (5 on 1 PCB)	934016	8.00	16.00
Voice operated recording	934039	6.00	12.00
General transformer PCB	934004	6.50	13.00
Plant humidity monitor	934031	4.50	9.00
Plant humidity monitor (supply)	934032	4.00	8.00
SEPTEMBER 1993			
Fuzzy logic multimeter - 1	920049-2	20.00	40.00
Linear temperature gauge	920150	7.05	14.10
Digital output for CD players	920171	Not available	
PC-aided transistor tester	920144	9.75	19.50
Harmonic enhancer	930025	13.50	27.00
I²C alphanumerical display (incl. disk 1851)	930044✛	14.25	28.50
Mini micro clock	930055	7.50	15.00
950-1750 MHz converter	UPBS-1	1.95	3.90
OCTOBER 1993			
Stereo mixer	UPBS-1	1.95	3.90
MIDI channel monitor	930059	14.00	28.00
Ah meter with digital display	930068	14.00	28.00
Autoranging frequency readout	930034	12.50	25.00
ROM-gate switchover for Atari ST	930005	30.25	60.50
Microntroller-driven NiCd battery charger (incl. programmed ST62E15)	920162✛	25.50	51.00
Fuzzy logic multimeter - 2 (incl. disk 1721)	920049-1✛	23.75	47.50

A list of all PCBs, software products and front panels available through the Readers Services is published in the March, June, September and December issues of *Elektor Electronics*.

ORDER FORM

10-93

VAT No. 454 135 463

Send this order form to *
Elektor Electronics (Publishing)
P.O. Box 1414
Dorchester DT2 8YH
ENGLAND

**USA and Canada residents only:* use $ prices, and send order form to:
Old Colony Sound Lab,
P.O. Box 243, Peterborough, NH 03458.
Tel. (603) 924-6371, 924-6526
Fax: (603) 924-9467

Name	
Address	
	Post code
Telephone	Date

Please supply the following. For PCBs, front panel foils, EPROMs, PALs, GALs, microcontrollers and diskettes, state the part number and description; for books, state the full title; for photocopies of articles, state full name of article and month and year of publication. Please use block capitals.

Qty.	Order code	Description	Price	Total
			Sub-total	
			P&P	
			Total paid	

Method of payment (see overleaf before ticking as appropriate)
Note: cheques not made out in sterling must be increased by the equivalent of £15.00

☐ Bank draft ☐ Cheque (payable to Elektor Electronics Publishing)

☐ Giro transfer (our account no. 34 152 3801)

☐ Postal/money order

☐ VISA Access MasterCard Eurocard Expiry date: ________ Signature: ________

International Subscription Service

Please enter my subscription to *Elektor Electronics*
for ☐ one year ☐ two years (tick as required)
by ☐ surface mail ☐ airmail (tick as required).

Method of payment (see overleaf before ticking as appropriate)

☐ Cheque enclosed (payable to Elektor Electronics Publishing)

☐ Giro transfer to a/c 34 152 3801

☐ Credit card Expiry date..............Signature ....

VISA Access MasterCard Eurocard

Name ....
Address ....
....
....Postal code ....
Telephone .... Date ....

Send this form to
Elektor Electronics, World Wide Subscription Service Ltd, Unit 4, Gibbs Reed Farm, Pashley Road, Ticehurst TN5 7HE, England
(Registered in the UK under the Data Protection Act, 1984)

10-93

TERMS OF BUSINESS

HOW TO PAY

Unless you have an approved credit account with us, all orders must be accompanied by the full payment, including postage and packing charges as stated on page 70, section 1.

Payment may be made by cheque **drawn on a London clearing bank** (but see para. 4 below), postal order, VISA, ACCESS, MASTERCARD or EUROCARD (when paying by credit card, the order must go to the cardholder's address). Do not send cash through the mail. Cheques and postal orders should be crossed and made payable to 'Elektor Electronics (Publishing)'.

Payment may also be made by direct transfer from a private or business Giro account to our **Giro Account No. 34 152 3801** by completing and sending to the National Giro Centre, in a National Giro postage paid envelope, a National Giro transfer/deposit form. Do not send Giro transfers direct to us, as this will delay your order.

If you live outside the UK, payment may also be made by Bankers' sterling draft drawn on a London clearing bank, Eurocheque **made out in pounds sterling** (with holder's guarantee card number written on the back), or US or Canadian dollar cheque, but such cheques, accepted at the exchange rate prevailing at the time your order is received, **must be increased by the equivalent of £15.00** to cover our bankers' negotiating fee.

If you pay by Bankers' sterling draft, make clear to the issuing bank that your full name and address MUST be communicated to the London clearing bank.

Our bankers are **National Westminster Bank PLC, 100 High Street, BRENTFORD TW8 8AY, England.** Our account number is **4285 0134**.

DELIVERY

Although every effort will be made to dispatch your order within 2–3 weeks from receipt of your instructions, we can not guarantee this time scale for all orders.

RETURNS

Faulty goods or goods sent in error may be returned for replacement or correction, but not before obtaining our consent. All goods returned should be packed securely in a padded bag or box, enclosing a covering letter stating the dispatch note number. If the goods are returned because of a mistake on our part, we will refund the return postage. Goods returned for refund must be in resaleable condition and will be subject to a 10% handling charge with a minimum charge of £2·50.

DAMAGED GOODS

Claims for damaged goods must be received at our Dorchester office within 10 days (UK); 14 days (Europe) or 21 days (all other countries) from the date on our "Recorded Delivery" slip.

CANCELLED ORDERS

All cancelled orders will be subject to a 10% handling charge with a minimum charge of £2·50.

PATENTS

Patent protection may exist in respect of circuits, devices, components, and so on, described in our books or magazines. Elektor Electronics (Publishing) do not accept responsibility or liability for failing to identify such patent or other protection.

COPYRIGHT

All drawings, photographs, articles, printed-circuit boards, EPROMS, and cassettes published in our books or magazines (other than in third-party advertisements) are copyright and may not be reproduced or transmitted in any form or by any means, including photocopying and recording, in whole or in part, without the prior permission of Elektor Electronics (Publishing) in writing. Such written permission must also be obtained before any part of these publications is stored in a retrieval system of any nature.

Nothwithstanding the above, printed-circuit boards may be produced for private and personal use without prior permission.

LIMITATION OF LIABILITY

Elektor Electronics (Publishing) shall not be liable in contract, tort, or otherwise, for any loss or damage suffered by the purchaser whatsoever or howsoever arising out of, or in connexion with, the supply of goods or services by Elektor Electronics (Publishing) other than to supply goods as described or, at the option of Elektor Electronics (Publishing), to refund the purchaser any money paid in respect of the goods.

LAW

Any question relating to the supply of goods and services by Elektor Electronics (Publishing) shall be determined in all respects by the laws of England.

April 1993

Annual subscription rates (1994)

United Kingdom	£27·00
Rest of the world (surface mail)	£33.00
AIRMAIL	
Europe & Eire	£34.00
USA & Canada	$57.00
Middle East & North Africa	£43·00
Central & southern Africa	£43·00
Central & South America	£43·00
Australia & New Zealand	£45·00
Far East & South Pacific regions	£45·00

Payment may be made by cheque in sterling **drawn on a London clearing bank** (but see below), postal order, VISA, ACCESS, MASTERCARD or EUROCARD (in which case the subscription must be sent to the cardholder's address) or by direct transfer to our Giro Account no. 34 152 3801. Do not send cash through the mail. Cheques and postal orders should be made payable to 'Elektor Electronics Publishing'. Giro transfers should be made by completing and sending the appropriate transfer/deposit form to the National Giro Centre (UK) or to your national Giro Centre.

If you live outside the United Kingdom, payment may also be made by Bankers' sterling draft drawn on a London clearing bank or Eurocheque. Eurocheques should be made out in pounds sterling and have the holder's guarantee card number written on the back.

US dollar cheques. Subscribers in the USA and Canada only may pay in $US cheques.

The **standard subscription order period** is twelve months. If a permanent change of address during your subscription period means that copies have to be dispatched by a more expensive service, no extra charge will be made. Similarly, no refund will be made, nor expiry date extended, if a change of address allows the use of a cheaper service.

Student applications, which qualify for a 10% (ten per cent) reduction in current rates, must be supported by evidence of studentship signed by the head of the college, school or university faculty.

Please note that **new subscriptions** take about four weeks from receipt of order to become effective.

Cancelled subscriptions will be subject to a charge of 25% (twenty-five per cent) of the full subscription price or £7.50, whichever is the higher, plus the cost of any issues already dispatched. Subscriptions cannot be cancelled after they have run for six months or more.

Our bankers are National Westminster Bank PLC, Sorting Code 60-03-23, 100 High Street, Brentford TW8 8AY, England. Our account number is 4285 0134.

June 1993

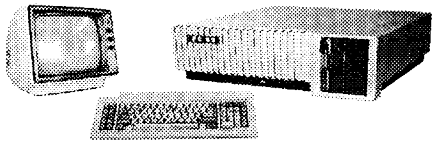
Surplus always wanted for cash!

THE *ORIGINAL* SURPLUS WONDERLAND!

Surplus always wanted for cash!

LOW COST PC SPECIALISTS - ALL EXPANDABLE - ALL PC COMPATIBLE

8088 XT - PC99

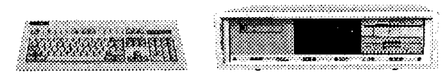


- 256k RAM - expandable to 640k
- 4.7 Mhz speed
- 360k 5-1/4" floppy
- 2 serial & 1 parallel ports
- MS-DOS 4.01
- Factory burnt-in
- Standard 84 key keyboard
- 12" green screen included
- In good used condition

Optional FITTED extras: 640K RAM £39. 12" CGA colour monitor with card £39. 2nd 5-1/4" 360K floppy £29.95. 20 mbyte MFM hard drive £99.

Only £99.00 (F)

286 AT - PC286

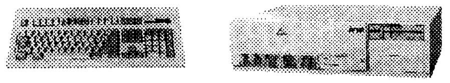


- 640k RAM expandable with standard SIMMS
- 12 Mhz Landmark speed
- 20 meg hard disk
- 1.2 meg 5-1/4" floppy
- 1.4 meg 3-1/2" floppy
- EGA driver on board
- 2 serial & 1 parallel ports
- MS-DOS 4.01
- Co-processor socket
- Enhanced 102 key keyboard
- Clock & calendar with battery back up

BRAND NEW AND BOXED!

Only £249.00 (F)

386 AT - PC386



- 2 meg RAM expanded by slots
- 20 Mhz with 32k cache. Expandable to 64k
- 40 meg hard disk
- 1.2 meg 5-1/4" floppy
- VGA card installed
- 2 serial & 1 parallel ports
- MS-DOS 4.01
- Co-processor socket
- Enhanced 102 keyboard
- Kwik Disk Accelerator Software - FREE

BRAND NEW AND BOXED!

Only £425.00 (F)

The Philips 9CM073 is suggested for the PC286 and the CM8873 for the PC386. Either may use the SVGA MTS-9600 if a suitable card is installed. We can fit this at a cost of £49.00 for the PC286 and £39.00 for the PC386.

FLOPPY DISK DRIVES

5¼" from £22.95 - 3½" from £21.95!

Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. **All are IBM-PC compatible** (if 3½" supported).

3.5" **Panasonic** JU363/4 720K or equivalent	**£29.95**(B)
3.5" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only*	**£29.95**(B)
3.5" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop	**£29.95**(B)
5.25" EXTRA SPECIAL BRAND NEW Mitsubishi MF501B 360K. Absolutely standard fits most computers	**£22.95**(B)

*** Data cable included in price.**

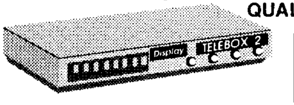
Shugart 800/801 SS refurbished & tested	**£175.00**(E)
Shugart 851 double sided refurbished & tested	**£275.00**(E)
Mitsubishi M2894-63 double sided switchable hard or soft sectors- BRAND NEW	**£250.00**(E)

Dual 8" drives with 2 mbyte capacity housed in a smart case with built in power supply! Ideal as exterior drives! **£499.00**(F)

End of line purchase scoop! Brand new **NEC D2246** 8" 85 megabyte of hard disk storage! Full CPU control and industry standard SMD interface. Ultra hi speed transfer and access time leaves the good old ST506 interface standing. In mint condition and comes complete with manual. Only........................**£299**(E)

THE *AMAZING* TELEBOX!

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER!

The TELEBOX consists of an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by manufacturers such as MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD and many more. The composite video output will also plug directly into most video recorders, allowing reception of TV channels not normally receivable on most television receivers (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television or video channels. TELEBOX MB covers virtually all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators. Composite and RGB video outputs are located on the rear panel for direct connection to most makes of monitor. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

Telebox ST	for composite video input monitors	**£32.95**
Telebox STL	as ST but with integral speaker	**£36.50**
Telebox MB	as ST with Multiband tuner VHF-UHF-Cable. & hyperband For overseas PAL versions state 5.5 or 6mhz sound specification.	**£69.95**
Telebox RGB	for analogue RGB monitors (15khz)	**£69.95**

Shipping code on all Teleboxes is (B)

RGB Telebox also suitable for IBM multisync monitors with RGB analog and composite sync. Overseas versions VHF & UHF call. SECAM / NTSC not available.

No Break Uninterruptable PSU's

Brand new and boxed 230 volts uninterruptable power supplies from **Densei**. Model MUK 0565-AUAF is 0.5 kva and MUD 1085-AHBH is 1 kva. Both have sealed lead acid batteries. MUK are internal, MUD has them in a matching case. Times from interrupt are 5 and 15 minutes respectively. Complete with full operation manuals............**MUK......£249** (F) **MUD......£525** (G)

POWER SUPPLIES

Power One SPL200-5200P 200 watt (250 w peak).Semi open frame giving +5v 35a, -5v 1.5a, +12v 4a (8a peak), -12v 1.5a, +24v 4a (6a peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims13" x 5" x 2.5". Fully guaranteed RFE.	**£85.00** (B)
Power One SPL130. 130 watts. Selectable for 12v (4A) or 24 v (2A). 5v @ 20A. ± 12v @ 1.5A. Switch mode. New.	**£59.95**(B)
Astec AC-8151 40 watts. Switch mode. +5v @ 2.5a. +12v @ 2a. -12v @ 0.1a. 6-1/4" x 4" x 1-3/4".New	**£22.95**(B)
Greendale 19AB0E 60 watts switch mode.+5v @ 6a,±12v @ 1a,+15v @ 1a. RFE and fully tested.11 x 20 x5.5cms.	**£24.95**(C)
Conver AC130. 130 watt hi-grade VDE spec.Switch mode.+5v @ 15a,-5v @ 1a,±12v @ 6a.27 x 12.5 x 6.5cms.New.	**£49.95**(C)
Boshert 13090.Switch mode.Ideal for drives & system. +5v@ 6a, +12v @ 2.5a, -12v @ 0.5a, -5v @ 0.5a.	**£29.95**(B)
Farnell G6/40A. Switch mode. 5v @ 40a.Encased	**£95.00**(C)
Farnell G24/5S. As above but 24v @ 5a.	**£65.00**(C)

BBC Model B APM Board

WIN £100 CASH!

£100 CASH FOR THE MOST NOVEL DEMONSTRATABLE APPLICATION!

BBC Model B type computer on a board. A major purchase allows us to offer you the **PROFESSIONAL** version of the BBC computer at a parts only price. Used as a front end graphics system on large networked systems the architecture of the BBC board has so many similarities to the regular BBC model B that we are sure that with a bit of experimentation and ingenuity many useful applications will be found for this board!! It is supplied complete with a connector panel which brings all the I/O to 'D' and BNC type connectors - all you have to do is provide +5 and ± 12 v DC. The APM consists of a single PCB with most major ic's socketed. The ic's are too numerous to list but include a 6502, RAM and an SAA5050 teletext chip. Three 27128 EPROMS contain the custom operating system on which we have no data, On application of DC power the system boots and provides diagnostic information on the video output. On board DIP switches and jumpers select the ECONET address and enable the four extra EPROM sockets for user software. Appx. dims: main board 13" x 10". I/O board 14" x 3". Supplied tested with circuit diagram, data and competition entry form.

Only £29.95 or 2 for £53 (B)

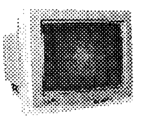
SPECIAL INTEREST

Trio 0-18 vdc bench PSU. 30 amps. New	£ 470
Fujitsu M3041 600 LPM band printer	£2950
DEC LS/02 CPU board	£ 150
Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBTF2 Modulator	£6500
Calcomp 1036 large drum 3 pen plotter	£ 650
Thurlby LA 160B logic analyser	£ 375
1.5kw 115v 60hz power source	£ 950
Anton Pillar 400 Hz 3 phase frequency converter 75Kw	POA
Newton Derby 400 Hz 70 Kw converter	POA
Nikon PL-2 Projection lens meter/scope	£750
Sekonic SD 150H 18 channel Hybrid recorder	£2000
HP 7580A A1 8 pen high speed drum plotter	£1850
Kenwood DA-3501 CD tester, laser pickup simulator	£ 350

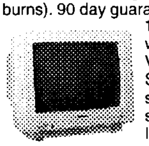
BRAND NEW PRINTERS

Microline 183. NLQ 17x17 dot matrix. Full width.	**£139** (D)
Hyundai HDP-920. NLQ 24x18 dot matrix full width.	**£149** (D)
Qume LetterPro 20 daisy. Qume QS-3 interface.	**£39.95** (D)
Centronics 152-2 9 x 7 dot matrix. Full width.	**£149** (D)
Centronics 159-4 9 x 7 dot matrix.Serial. 9-1/2" width	**£ 99** (D)

MONITORS

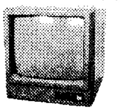


14" Forefront Model MTS-9600 SVGA multisync with resolution of 1024 x 768. 0.28 pitch. "Text" switch for word processing etc. Overscan switch included. Ideal for the PC-386 or PC-286 with SVGA card added. Also compatibe with BBC, Amiga, Atari (including the monochrome high resolution mode), Archimedes etc. In good used condition (possible minor screen burns). 90 day guarantee. 15" x 14" x 12". Only.............**£159**(E)



14" Philips Model CM8873 VGA multisync with 640 x 480 resolution. CGA, EGA or VGA, digital/analog, switch selectable. Sound with volume control. There is also a special "Text" switch for word processing, spreadsheets and the like. Compatible with IBM PC's, Amiga, Atari (excluding the monochrome high resolution mode), BBC, Archimedes etc. Good used condition (possible minor screen burns) 90 day guarantee. 15" x 14" x 12". Only ....**£139**(E)

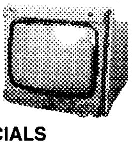
Philips 9CM073 similar (not identical) to above for **EGA/CGA** PC and compats. 640 x 350 resolution. With Text switch with amber or green screen selection. 14" x 12" x 13-1/2"........**£99**(E)



KME 10" high definition colour monitors. Nice tight 0.28" dot pitch for superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13.5" x 12" x 11". Also works as quality TV with our RGB Telebox. Good used condition. 90 day guarantee. Only..**£125** (E)

KME as above for PC EGA standard.........................£145 (E)

Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubishi 0.42 dot pitch giving 669 x 507 pixels. Big 28 Mhz bandwidth. A super monitor in attractive style moulded case.Full 90 day guarantee. Only .... **£129** (E)



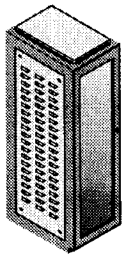
NEC CGA 12" IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15"L x 13"W x 12"H. The front cosmetic bezel has been removed for contractual reasons. Only......... **£69** (E)

20", 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & sound inputs. Attractive teak style case. Perfect for Schools,Shops,Disco, Clubs. In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

CALL FOR PRICING ON NTSC VERSIONS!



Superb Quality 6 foot 40u

19" Rack Cabinets

Massive Reductions

Virtually New, Ultra Smart!

Less Than Half Price!

Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels or stand singly. Overall dimensions are 77-1/2"H x 32-1/2"D x 22"W. Order as:

Rack 1 Complete with removable side panels.......	**£275.00** (G)
Rack 2 Less side panels	**£145.00** (G)

1992 Winter Issue of *Display News* now available - send large SAE - PACKED with bargains!

DISPLAY
-ELECTRONICS-

MAIL ORDER & OFFICES
Open Mon-Fri 9.00-5.30
Dept EL, 32 Biggin Way,
Upper Norwood,
London SE19 3XF.

LONDON SHOP
Open Mon-Sat 9-5.30
Thursday till 9.00pm
215 Whitehorse Lane,
South Norwood,
London, SE25 .

DISTEL © The Original
Free dial-up database!
1000's of items+info on line
V21, V22 & V22 bis
081-679-1888

ALL ENQUIRIES
081-679-4414
Fax- 081-679-1927

Access
Visa

All prices for UK Mainland. UK customers add 17.5% VAT to TOTAL order amount. Minimum order £10. PO orders from Government,Universities,Schools & Local Authorities welcome-minimum account order £30. Carriage charges (A)=£2.00. (A1)=£3.75. (B)=£5.50. (C)=£8.50. (D)=£11.50. (E)=£14.00 (F)=£18.00 (G)=Call . Scotland surcharge: call. All goods supplied subject to our standard Conditions of Sale and unless otherwise stated guaranteed for 90 days. All guarantees on a return to base basis.Rights reserved to change prices & specifications without prior notice. Orders subject to stock. Quotations willingly given for higher quantities than those stated. Bulk surplus always wanted for cash.

ELEKTOR ELECTRONICS is available from, among others:

CRICKLEWOOD ELECTRONICS LIMITED
40 Cricklewood Broadway,
London NW2 3ET
Telephone 081 450 0995
Fax 081 208 1441

THE ELECTRONIC SHOP
Electronic components, test equipment, telephone accessories, computer accessories, microphones, disco lighting, speakers, turn tables, mixers, meters, stylus.
29 Hanging Ditch,
Manchester M4 3ES,
Telephone 061 834 1185

ELEY ELECTRONICS
100–104 Beatrice Road
Leicester LE3 9FF
Telephone (0533) 515 944

GREENWELD
27 Park Road
Southampton SO1 3TB
England
Telephone (0703) 236 363
Fax (0703) 236 307

L.F. HANNEY
Your electronic component specialist for Avon, Wilts & Somerset.
77 Lower Bristol Road, Bath,
Avon, Telephone 0225 424811

D.P. HOBBS (NORWICH) LTD
Electronic component specialists. Amateur radio equipment.
13 St. Benedict Street,
Norwich NR2 4PE,
Telephone 0603 615786

MANCOMP
240 Platt Lane
Manchester M14 7BS
England
Telephone 061 224 1888

OMNI ELECTRONICS
Stock a wide range of electronic components.
174 Dalkeith Road,
Edinburgh EH16 5DX,
Telephone 031 667 2611

AAGE NIELSEN
1 Sortedam Dosseringen
DK-2200 Copenhagen,
Denmark,
Telephone 01 39 30 10
Fax 031 39 05 02

HELMHOLT ELEKTRONIK
Farvevej 2
DK-7600 Struer, Denmark
Telephone 97 85 26 11

RCE ELECTRONIC CENTRE
Boulevarden 34
DK-9000 Aalborg, Denmark
Telephone 98 16 07 10

VEJLE RC ELEKTRONIK
Sdr Brogade 42
P O Box 332
DK-7100 Vejle, Denmark
Telephone 75 83 25 33

BEBEK ELECTRONICS
Hirsimetsäntie 26
SF-15200 Lahti 11
Finland
Telephone (18) 33 99 46

TABACCARIA BRITANICA
Praça do Duque da
Terceira 19
1107 Lisboa, Portugal
Telephone 932 4752

MK KNJIGARNA
Slovenska 29
Ljubljana
Slovenia
Telephone 061 150 196

TECHNICAL BOOKS & MAGAZINES
289-299 Swanston Street
Melbourne, Australia 3000
Telephone 663 3951

INEL Co.
P.O. Box 1397
JL. Hariang Banga No. 3
Bandung 40116
Indonesia

ADVERTISING IN *Elektor Electronics*

The closing date for copy is five weeks before publication date (four weeks for camera-ready copy). Colour advertisements should be submitted on film separations. *Elektor Electronics* is published on the third Thursday of the month preceding cover date.

Elektor Electronics (Publishing) will not be liable for any loss caused by the failure of any advertisement to appear for any reason, and they do not accept liability for printers' errors, although every care is taken to avoid mistakes.

Copy instructions, artwork and all correspondence pertaining to advertisements should be addressed to

Elektor Electronics (Publishing)
Advertisement Office
3 Crescent Terrace
CHELTENHAM GL50 3PE
England
Telephone (0242) 510 760
FAX (0242) 226 626

INDEX OF ADVERTISERS

Advertising Standards Authority	39
Badger Boards	20
Baylin Publications	39
B K Electronics	13
Bull Electrical	56
Cirkit Distribution	63
Comdis Nederland	63
Cricklewood Electronics	43
Display Electronics	73
Dubery Associates	43
ElectroValue	57
Elektor Electronics	7, 38, 69, 74
ESR Electronic Components	27
HCT Electronics	57
ICE Technology	Inside back cover
Instrutek (UK)	21
J P Distribution	63
Labcenter Electronics	29
Macro Cross Assemblers	39
Maplin Electronic Supplies	Back cover
John Morrison (Micros)	20
Number One Systems Ltd	4
Pico Technology Ltd	37
POWERware	47
Roline Systems Ltd	69
Smart Communications	39
Stewart of Reading	57
Suma Designs	28
Tsien (UK) Ltd	51
Ultimate Technology	Inside front cover
Viewcom Electronics	14, 15
White House Systems	57
ZE Systems	7

THE BEST LOW COST PROGRAMMERS
DESIGNED & MANUFACTURED IN THE UK

SPEEDMASTER 1000
SPEEDMASTER 1000E
UNIVERSAL PROGRAMMER

- Superfast PC based programmer
- Programmes; EPROMS UP TO 8M BIT, FLASH EPROMS, EEPROMS, BPROMS, NVRAMs, MICROs (8748/51), PALs, GALs, EPLDs, PEELS, MACHS, MAPLs, MAX
- Plugs directly into parallel port
- 1000E Version has ROM/RAM emulator built in: 128k (1 Mbit) standard, optional 512K (4Mbit)

only £445

only £525

MICROMASTER 1000
MICROMASTER 1000E
UNIVERSAL PROGRAMMER

- Programmes: EPROMS UP TO 8M BIT. FLASH EPROMS, EEPROMS, BPROMS, NVRAMs, PALs, GALs, EPLDs, PEELs, MACHs, MAPLs, MAX etc.
- PLUS over 80 different Micros including 8748/51, 68HC705, 68HC711, PICs, Z86, TMS320, TMS370 etc DIPs WITHOUT ADAPTORS OR PERSONALITY MODULES!
- Package adaptors available.
- 1000E Version has ROM/RAM emulator built in: 128K (1Mbit) standard, optional 512K (4 Mbit)

only £575

only £645

SPEEDMASTER 8000
GANG/SET PROGRAMMER

- 8 way, Pc or stand alone
- Super-fast programming times, manufacturer recommended algorithms
- 32 pin devices as standard
- Support for 8748,51, TMS370, PIC Micros and 40 pins.

only £645

Now includes digital IC and RAM tester

WHY BUY AN INFERIOR IMPORTED PROGRAMMER WHEN YOU CAN HAVE A MANUFACTURER APPROVED UNIVERSAL PROGRAMMER/EMULATOR DIRECT FROM ICE TECHNOLOGY!

- ☐ We offer the best range of low-cost programmers available, now including our unique **UNIVERSAL PROGRAMMERS WITH BUILT IN EMULATORS**
- ☐ Unrivalled device support, for example the Micromaster 1000 programmes PICS, Z86, 87C705, 68HC705, TMS370, 77C82 ETC WITHOUT ADAPTORS, as well as the full range of Eproms, PLDs etc supported by all our universal programmers.
- ☐ Approved by National Semiconductor for their full range of PALs, GALs, and MAPLs - other programmers claiming approval are often only approved for EPROMs - a much less exacting specification!
- ☐ All our programmers and programme/emulators work off the standard parallel port with any IBM compatible PC, even laptops
- ☐ Unbeaten programming times: Programme a 27256 in just 5 SECONDS including download and verify.
- ☐ Easy upgrade path between Models.

FOR MORE DETAILS, DEVICE LIST AND DEMO DISK CALL NOW ON
TEL +44 (0)226 767404 FAX +44 (0)226 370434

ICE TECHNOLOGY LTD, UNIT 4, PENISTONE COURT, STATION BUILDINGS, PENISTONE, S. YORKS, S30 6HG, UK.

ICE TECHNOLOGY

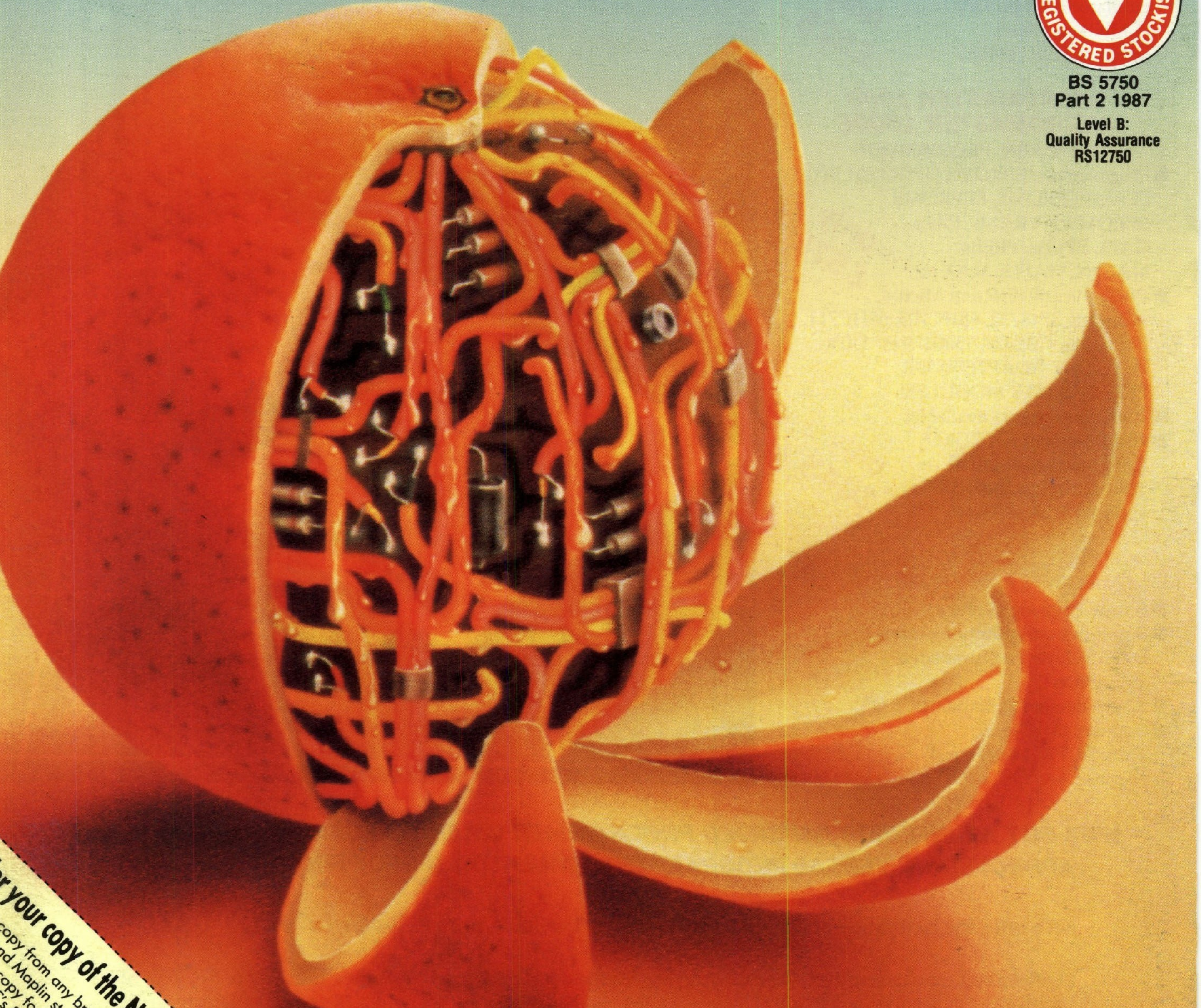
NEW

FULL COLOUR GUIDE TO ELECTRONIC PRODUCTS

Maplin

BSI
REGISTERED STOCKIST

BS 5750
Part 2 1987
Level B:
Quality Assurance
RS12750



Order your copy of the New MAPLIN Catalogue on sale NOW!

Pick up a copy from any branch of **WHSMITH**, selected branches of **RSMcCOLL** in Scotland ONLY, and Maplin stores nationwide for just £2.95 or post this coupon now to receive your copy for just £3.45 inc. p&p. If you live outside the U.K. send £6.80 or 18 IRC's for Airmail in Europe/£5.20 or 13 IRC's for surface mail outside Europe; or £11.50 or 30 IRC's for Airmail outside Europe.

I enclose £3.45/£6.80/£5.20/£11.50 (delete as applicable).

Name...
Address...
....
.... Post Code ....

Send to Maplin Electronics,
P.O. Box 3, Rayleigh,
Essex, England
SS6 8LR.

ELK94

Over 700 colour packed pages with hundreds of brand New Products at Super Low Prices, on sale now, **only £2.95.**

Available from all branches of **WHSMITH,** selected branches of **RSMcCOLL** in Scotland ONLY, and Maplin stores nationwide.
The Maplin Electronics 1994 Catalogue – **UNIQUELY DIFFERENT!**